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Natural Resource Stewardship and Science

Invasive Exotic Plant Monitoring (Year 2) and Treatment Recommendations for Arkansas Post National Memorial

Natural Resource Technical Report NPS/HTLN/NRTR—2012/609

ON THE COVER
Common periwinkle growing as an understory plant in the Memorial Unit forest, Arkansas Post National Memorial.
Photograph by: Adam Throckmorton, National Park Service

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Executive Summary

In some cases, cultural landscapes require invasive plant management treatments to maintain these historic sites. The cultural landscape report for Arkansas Post National Memorial outlines the importance of invasive plant management in general, while also identifying 11 non-native species, and listing three species – Chinese privet, Japanese honeysuckle, and trifoliate orange - as specifically requiring control (Quinn Evans 2005). Based on our reading of the cultural landscape report, an evaluation of each plant's abundance and distribution in the park, and consideration of the biology of each species, we recommend treatments for 16 of 26 invasive plant species identified in this study. The decision to treat each species was not determined by a formula, but was assisted by characterizing the purpose of management for each species using a series of scenarios. In our opinion, these recommendations are in accordance with the treatments outlined in Chapter 6 of the cultural landscape report, but require further evaluation through the National Environmental Policy Act and National Historical Preservation Act processes.

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Introduction

Cultural Landscapes and Invasive Plants

In every national park, the value of a landscape is, to some extent, in the eye of the policy, the manager, the expert, the citizen, and the traditional user. The history of the National Park Service (NPS) is one of continually adjudicating the values of use, scenic landscape management, natural resource protection, and cultural resource preservation (Sellars 2009). The inevitable synergies and conflicts among these values trigger much of the decision making required of National Park Service officials. Management policies, general management plans, cultural landscape reports, and environmental and historic preservation compliance are just a few of the written records that continually assist officials in protecting, and, when needed, negotiating among these values.

A cultural landscape is defined as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values" (Birnbaum 1994). As such, the concept is comprehensive of entire parks. In some cases, extensive cultural practices or wide-ranging plants or animals with ethnographic or historic significance may comprise an entire park (Evans 2009). In historic sites and sites "managed as historic", however, the distinguishing cultural landscape features (referred to as "contributing features" in cultural landscape documents) are typically spatially restricted. For example, historic structures, earthworks, gardens, home sites, and archaeological sites can be readily assessed for the National Register of Historic Places and managed because of their limited spatial extent. While historical landscape architects document these historic features under section 110 of the national Historic Preservation Act, cultural landscape reports recommend treatments based on an analytical process that evaluates integrity relative to a period of significance.

Treatments as defined in a cultural landscape report, typically fall into one or a combination of categories: preservation, restoration, or rehabilitation for a site or district as eligible for or listed on the National Register, defined by a park's legislation, or specified in a park management plan to be "managed as historic". With regard to vegetation, a cultural landscape may, if determined to be significant and/or compatible, include park operations areas, such as lawns and landscaping; areas in which vegetation is "rehabilitated"; and largely unmanaged "natural areas" because the vegetation is compatible with the park mission and may enhance the cultural landscape's setting, feeling, and association qualities, despite a lack of individual historic integrity. "Natural", in this case, implies the absence of very recent human disturbance, and does not necessarily suggest biological significance, as is associated with the terms "research natural area", a special land designation within NPS, or "natural area" as used in the in the ecological literature.

Invasive plants in cultural landscapes require a set of considerations that differ from the concerns related only to the ecological impact of these species. We use the term "invasive plant" as defined in Executive Order 13112 as a non-native plant "whose introduction does or is likely to cause economic or environmental harm or harm to human health". In some situations, cultural landscape considerations increase the clarity surrounding decisions to manage invasive plants. We adopt an approach of starting with clear, straightforward examples of invasive plant management needs in cultural landscapes and working towards less clear, and often more complex examples.

Invasive Plant Management Scenarios in Cultural Landscapes (Figure 1)

First and foremost, managing invasive plants in cultural landscapes requires preventing unintentional degradation of cultural or natural resources (NPS 2006). This intention is manifest in the Organic Act, establishing the National Park Service, and is further realized within the NPS management policies (2006). Processes outlined under the National Environmental Policy Act and the National Historic Preservation Act structure decision making processes to protect natural and cultural resources while inviting public involvement. Interestingly, invasive plants may be designated as "biotic cultural resources" due to their ethnographic or historic significance (NPS 2006). Typically, however, such plants are incorporated in a recognized cultural landscape, including ethnographic landscapes, historic designed landscapes, historic vernacular landscapes, or historic sites. Managing invasive plants should also not incidentally degrade historic structures or archaeological sites. In rare cases, invasive plants may stabilize archaeological sites, earthworks, or historic buildings. For example, English ivy growing on a historic structure may become integral to the historic fabric and should only be removed based on treatment recommendations found in a historic structures report despite its invasive tendencies. Cultural landscape, ethnographic, and archaeological studies are vital for identifying invasive plants to preserve or control in order to protect cultural and natural resources.

Non-native plant species may also perform certain important functions within parks. Non-native plants may substitute for a closely related native species or be cultivated in areas where native plant alternatives are not suitable to support visitor use or to control erosion (NPS 2006). In these situations, the invasive plant is not a cultural resource nor is it intimately connected to such a resource. The plant may, however, enhance the setting, feeling, or association providing historic context or may serve an important function such as erosion control. The beneficial service that the plant provides in this scenario may be greater than the risk of the plant from spreading beyond the interpretive or historic area. Native species, however, are often available to meet most park needs; consultation with plant materials experts may lead to the identification of appropriate native plants.

After adequately considering cultural resource protection, park resource managers must prioritize invasive plant management needs. Virtually all parks support numerous non-native species; managers are not required to eradicate or control all of these species. Rather mangers must determine if control is "prudent and feasible" and if the plant causes one or more of the following impacts (NPS 2006):

1. Interferes with natural processes and the perpetuation of natural features, native species, or natural habitats; or
2. Disrupts the genetic integrity of native species; or
3. Disrupts the accurate presentation of a cultural landscape; or
4. Damages cultural resources; or
5. Significantly hampers the management of park or adjacent lands; or
6. Poses a public health hazard as advised by the U.S. Public Health Service (which includes the Centers for Disease Control and the NPS public health program); or
7. Creates a hazard to public safety.

While these impact criteria provide helpful guidelines in prioritizing invasive plant management actions, the large number of decisions required to move towards specific management approaches and actions in particular parks is often unrecognized.

Invasive plant management treatments that clearly protect earthworks or archeological sites are obvious priorities as described in criterion #4 (see above). Treatments required to protect the historic fabric or integrity of historic buildings or structures also qualify as high priorities. (As stated above, invasive plants may protect resources or provide important historic context and would not be controlled in these cases.) The sensitivity of these resources, however, requires extremely close coordination and planning with cultural resource experts. Consequently, park managers should only conduct these projects after such coordination has occurred.

From a park operations perspective, invasive plants may only be a special case of normal maintenance projects as described in criterion #5 and #7 (see above). Invasive plants, like numerous native species, may threaten visitor safety as hazard trees or as poisonous plants. In agricultural areas within parks, invasive plants may need to be controlled prior to planting. In open fields, invasive plants may be among the woody plant species that require periodic removal in order to hay or mow a site or depict a specific stage of succession. Treatment of invasive plants in these instances happens without explicit consideration of their invasive status. The problem presented by the plant may be amplified, however, because of its ability to reproduce or spread rapidly.

On most parks designated for the protection of historic and cultural resources, invasive plant treatment many be required (as outlined in cultural resource management documents) to maintain a high level of resource integrity. We suspect that the features requiring such attention are generally spatially-restricted in size and include features such as historic horticultural plantings; areas designated as important for education and interpretation; small-patch plant communities or habitats of known biological significance; areas that protect rare, historic, or ethnographically significant plants; and vegetation actively rehabilitated to represent a natural or cultural feature. In accordance with criterion # 1 and #3, invasive plant species should be eradicated or controlled in these areas provided that the resources are not harmed in the process. The limited size of these areas should result in an effort that is usually feasible.

Decisions related to invasive plant management become more complex in areas where cultural landscape features are not designated as contributing features, where active landscape treatments are not required, or where biological significance is negligible. In these situations, vegetation may still contribute to the cultural landscape, and native plant species are typically preferred over non-native species. Within cultural landscape reports, resource professionals may even recommend general conservation goals for these areas such as provision of habitat for wildlife. At this point, managers must consider numerous criteria including:

1. The contribution or potential (short-term or long-term) contribution of the vegetation to the park's designated purpose.
2. Secondary and often more general natural or cultural values associated with the vegetation.
3. Natural processes or management actions affecting the vegetation.
4. Potential spread and impact of particular invasive plant species.

5. Feasibility, in terms of cost, personnel, time commitment, availability of controls, and non-target impacts required for control.

If allowed under a recognized treatment plan, we suggest that park managers first simplify their decisions based solely on the designation of a plant species as invasive and its abundance in the park, which addresses criteria #4 and #5 above. Park managers should determine invasive potential based on scientific literature, gray literature, reported observations within relevant communities of practice, and park management discretion. Abundance may then serve as a proxy for project feasibility as small populations will generally require less time and treatment risks than widespread populations. Eradication from the park is much more likely at this point. In such cases, the time to cover the park searching for the plant is likely the limiting factor. In instances where the entire park cannot be searched, managers may focus on known or suspected geographic areas, physical features such as roads, trails, and streams, or other habitat characteristics that will increase the probability of detection. Despite the expectation of minimized non-target effects, parks must still consider the feasibility of such efforts and potential impacts on park resources.

In the most complex scenario, invasive species are relatively widespread such that eradication is at best a long-term and expensive prospect. The rationale for control in these situations should follow a multi-criteria approach to risk assessment, while inevitably involving a high degree of uncertainty.

Cooperation may increase the "prudence and feasibility" of a project, which may affect the prioritization or the approach taken to manage a particular invasive plant. For example, managers may determine that local efforts cannot successfully control a regionally-established invasive plant species in isolation. If site conditions cannot be changed, re-invasion on the park following treatment would be expected. Cooperative efforts that reduce the probability of re-invasion, however, may elevate the importance of a project. Parks may participate in voluntary cooperative efforts that attempt to control invasive plant species within a larger geographic area. Partnerships between private, non-profit, and government landowners, such as cooperative weed management areas, may organize such initiatives. Cooperative efforts may also be required under state laws. State weed laws, designed primarily to protect agricultural investments, require landowners to control plants that may spread to neighboring properties. As with park-based projects, cooperative efforts that target invasive plant species at an early stage of invasion stand a greater chance for success. Parks must still consider the feasibility of collaborative efforts and potential impacts on park resources.

These invasive plant scenarios for cultural landscapes are summarized in Figure 1. We will use these scenarios to guide recommendations for treatment of various invasive plant species in Arkansas Post National Memorial.

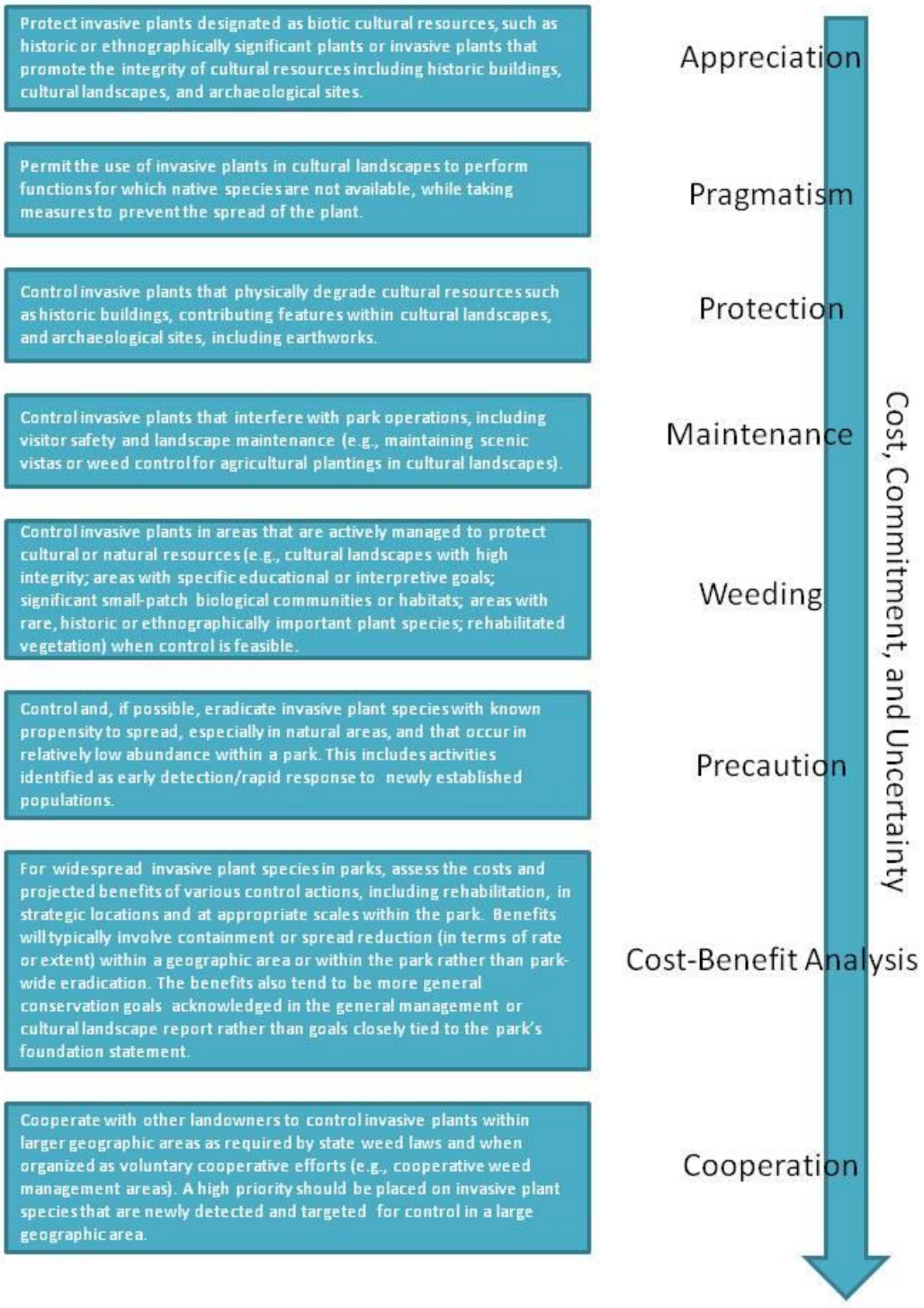

Figure 1. Organization of invasive plant management scenarios applied to cultural landscapes within national park. The scenarios are organized along an axis that generally corresponds with increasing complexity, cost, commitment, and uncertainty associated with the control of a particular invasive plant species. Uncertainty, in this case, refers to uncertainty in the magnitude of the problem caused by an invasive plant as well as uncertainty related to the prospect of control of that plant.

Vegetation within the Cultural Landscape of the Memorial Unit, Arkansas Post National Memorial

The cultural landscape of the Memorial Unit (Figure 2) at Arkansas Post National Memorial reflects its history of extensive use. The Memorial Unit is located near the highly strategic confluence of the Arkansas, White, and Mississippi Rivers. Archaeological and historical research indicated that this area supported at least some Native American activities and, beginning in 1686, European settlement. Acquired as part of the Louisiana Purchase in 1804, the site served as Arkansas' territorial capital from 1819 to 1821. The site later served as a Confederate fort, which Union troops captured after extensive bombardment in 1863. Following the Civil War, small white and African American farming communities surrounded the site. The site was later developed as a state park during the Great Depression and managed as such until its adoption as a National Park unit in 1960. Improvements under the National Park Service fostered a park-like feel designed to increase interpretive and recreational opportunities for visitors.

Because of this varied land use history, the landscape features, including the vegetation, do not cohesively represent any era of its history (Quinn Evans 2005). The long history of activities following European settlement led to the clearing of forests from the site. Construction of the McClellan-Kerr navigation system inundated much of the site in the 1960s, including the original location of Fort Hindman. Only "domestic clusters" of ornamental species attest to old home sites within the park from the post-Civil war era, while a single relatively dense stand that includes larger diameter trees offers a faint semblance of pre-settlement conditions (Quinn Evans 2005). Aerial photographs from 1955 showed the park largely in open fields and sparsely wooded areas. This disturbance history explains the 16 distinct vegetation types delineated in the 390-acre area and the recommendation in the 1978 master plan that the park should not manage the vegetation to reflect a particular historic period (Quinn Evans 2005).

The cultural landscape report concluded that "rehabilitation" of the landscape was the appropriate management paradigm in the Memorial Unit. Rehabilitation allows for changes that are compatible with other historic features, but does not attempt to preserve or accurately reconstruct the cultural landscape (Birmbaum 1994). The contributing vegetation features in the park include (Quinn Evans 2005):

1. Dense forest north of the picnic area entry drive (pre-1673)
2. Cleared land in the southern portion of the site (1673-1803)
3. Deciduous trees from the first half the 19th century (1804-1855)
4. Views east to approximate Fort Hindman location (1856-1865)
5. Moderately dense forest north of the picnic area entry drive (1866-1928)
6. Small clearing along existing north-central boundary (1866-1928)
7. Open unwooded land (for cultivation) in existing prairie south of existing picnic area (1866-1928)
8. Open, unwooded land in southern part of site in the Post of Arkansas vicinity (1866-1928)
9. Remnants of domestic, commercial, and agrarian life in central [Arkansas Post National Memorial] that include but are not limited to portions of building foundations, brick walks, house yard and field fences, fenceline and boundary vegetation, shade and fruit trees, the cattle corral and dipping vat site, cisterns and wells, and ornamental vegetation

such as daffodils, lily of the valley, dragon wort, crepe myrtle, privet, and daylilies (1866-1928).

Three of the nine treatment goals apply to the management of vegetation. These include:

1. The preservation of extant features and qualities that survive from significant historical periods or possess the ability to evoke those eras and contribute to integrity of the [Arkansas Post National Memorial].
2. Protect the scientific and interpretive value of the site's natural resources.
3. Remove invasive exotic species that threaten other natural and cultural features.

At Arkansas Post National Memorial, the recommendations in the Cultural Landscape Report regarding invasive plant management require a careful analysis. A number of non-native plants including "privet, Osage orange, pecan, apple, privet, mock orange, arum italicum, cottonwoods, trifoliate orange, [and] periwinkle" as well as "daffodils, lily of the valley, dragon wort, crepe myrtle, privet, and daylilies" were recognized as representative of the post-Civil War era. Furthermore, Japanese honeysuckle was noted as a potential ethnographic resource. In addition to specifically identifying these species, the document also identifies 11 invasive plant species and recommends control more generally for invasive plants "that threaten natural and cultural features." Recognizing these complexities within the cultural landscape report is important as park managers make decisions regarding invasive plant management.

A cultural landscape report is currently being developed for the Osotouy Unit (Figure 2) acquired by the NPS in 1997. The unit was not part of the scope of work and cost estimates for inclusion in the 2005 cultural landscape report. Consequently, any recommendations presented here apply only to the park's Memorial Unit.

Methods

Watch lists

Invasive exotic plant species on three watch lists were sought during monitoring (Table 1). Plants designated as high priority invasive species (Young et al. 2007a) and known to occur in the same state as the park, but not on the park per NPSpecies (NPS 2012) constituted the "early detection watch list". Designated invasive exotic plants known to occur on the park per NPSpecies constituted the "park-established watch list". Invasive exotic plants on the "park-based watch list" included plants selected by park managers or network staff that were not designated as invasive in the protocol, but may not have been included due to incomplete information in NPSpecies (i.e., not documented) or inaccurate information in the USDA Plants database (i.e., state distribution information inaccurate) or simply due to differing opinions regarding Heartland Network's designation. NPSpecies also provided an estimate of the total number of non-native plant species known form the park. While aquatic species were listed on the watch lists, terrestrial plants were the focus of this survey.

Field methods

Invasive exotic plant species on designated watch lists (Table 1) were sought throughout the Memorial and Osotouy Units of Arkansas Post National Memorial (Figure 2 and 3). Dan Tenaglia conducted field work during August 30-September 7, 2006 using a MobileMapper GPS Unit. Dr. Steven Brewer with Copperhead Consulting and Kyla Hershey with Lawhon and Associates, Inc. used a Garmin 60CSx and Trimble Instruments model GeoXT handheld GPS units to conduct the second survey during August 8-14, 2011. Surveys were conducted in search units, approximately 2 acres in size (Figures 2 and 3). Three equidistant passes through each search unit were made, though entire polygons were not fully searched. Observers recorded line transects to identify invasive exotic plants in an approximately 3- to 12-m belt. The widest belt possible was used, but varied depending on site conditions. Belt widths likely also varied to some degree among observers. Coarse cover values (0=0, 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2) were attributed to each species per search unit. A total of 507 transects within 169 search units were searched.

Analytical methods

A park-wide cover range was estimated for each invasive plant species encountered. First, calculations of the observed reference frame fraction were made by multiplying transect length, the number of transects, and the belt width. The belt width was either 3 m (the minimum possible width) or 12 m (the maximum possible width). Transect length was calculated by summing the lengths of the transects. The product was then divided by the reference frame area (Eq. 1).

$$\text{Eq.1. Fraction of area searched} = \frac{\textit{transect length} * \textit{number of transects} * \textit{belt width}}{\textit{reference frame area}}$$

The minimum fraction of area searched (belt width = 3 m) was 10%, and the maximum fraction of area searched (belt width = 12 m) was 40%.

To calculate the minimum of the estimated cover range for each species, the lower endpoints associated with the assigned cover class values for that species were summed and then divided

by the reference frame fraction observed assuming the widest possible survey belt (i.e., maximum fraction observed) (Eq. 2).

$$\text{Eq.2. Minimum cover estimate} = \frac{\Sigma \text{ low end of cover value range for species}}{\text{fraction of area searched assuming 12-m belt width}}$$

Maximum cover for each species was calculated similarly, summing the upper endpoints of the cover values in each occupied search unit and assuming that a 3-m belt was surveyed (i.e., minimum fraction of area observed) (Eq. 3).

$$\text{Eq. 3. Maximum cover estimate} = \frac{\Sigma \text{ high end of cover value range for species}}{\text{fraction of area searched assuming 3-m belt width}}$$

Taken together, the minimum and maximum cover estimates provide an estimated range of cover that accounts for the uncertainty arising from the sampling method. Non-overlapping ranges represented the strongest evidence for differences in abundance. The park-wide frequency of invasive exotic plants was then calculated as the percentage of occupied search units (Eq. 4).

$$\text{Eq. 4. Frequency of an invasive plant species} = \frac{\Sigma \text{ search units occupied by species}}{\Sigma \text{ search units sampled}} \text{ X100}$$

Finally, maps were created for each target invasive plant species. The maps indicated which search unit was occupied and the estimated cover class value for that search unit.

Invasiveness ranks

In order to provide additional information on the ecological impact and feasibility of control, the ecological impact and general management difficulty sub-ranks that constitute the invasiveness rank (I-rank), as determined by NatureServe (Morse et al. 2004), were listed when available. The ecological impact characterized the effect of the plant on ecosystem processes, community composition and structure, native plant and animal populations, and the conservation significance of threatened biodiversity. General management difficulty ranks were assigned based on the resources and time generally required to control a plant, the non-target effects of control on native populations, and the accessibility of invaded sites. Sub-ranks were given as high (H), medium (M), low (L), insignificant (I), unknown (U), or a combination of ranks.

Results and Discussion

We identified a cumulative total of 26 out of the 115 invasive plant species occurring on all three watch lists during the surveys in 2006 and 2011 (Table 2). Of these, 9 invasive plant species occurred on the early detection list of 93 species, and 13 species were on the park established list of 18 species. An additional four species noted as park-based species were not judged as highly problematic during the prioritization process. Subsequent results and discussion only address the 22 species on the early detection and park established watch lists.

Biological Considerations Affecting Invasive Plant Management Decisions

Analysis of Control Efforts to Date

Since 2006, only black locust (*Robinia pseudoacacia*), hardy orange (aka trifoliate orange, *Poncirus trifoliata*), and Chinese privet (*Ligustrum sinense*) have been widely controlled within the Memorial Unit using cutting and herbicide. These efforts explain the dramatic 23-fold decrease in the maximum cover of hardy orange. (Its frequency also decreased by 21%). Although the abundance ranges still overlapped, the 62% decline in the maximum abundance estimate of Chinese privet also presumably reflected control efforts. Despite a 10% decrease in its frequency, the plant was still widely distributed throughout the park. Control efforts apparently did not strongly affect black locust, which showed little change in abundance or frequency.

Need for Control Based on Increasing Plant Abundance and Ecological Impact

As a first look at invasive plant management decisions, plants that are increasing in abundance may be prioritized more highly for treatment. Only the abundance of Bermudagrass (*Cynodon dactylon*) increased between 2006 and 2011 as determined by non-overlapping abundance ranges. Although the abundance ranges overlapped, the abundance of alligatorweed (*Alternanthera philoxeroides*) and Johnsongrass (*Sorghum halepense*) increased approximately 7-fold, which may also suggest an increase in their abundance within the park.

The ecological impact of the majority of species was relatively low. Only a single species, giant reed (*Arundo donax*), was noted as having high ecological impact. Four species - including three wetland species alligatorweed, common water hyacinth (*Eichornia crassipes*), and narrowleaf cattail (*Typha angustifolia*) - as well as black locust were designated as having a “high/medium” impact. Chinese privet, Nepalese browntop (aka Japanese stiltgrass, *Microstegium vimineum*), Japanese honeysuckle (*Lonicera japonica*), and wart-removing herb (*Murdannia keisak*) were identified as having medium ecological impact. The remaining 13 invasive plant species were all ranked as having impact less than “medium”.

Prospects for Control Based on Abundance and Growth Form

Based only on abundance data, the prospects for early detection and eradication appear promising for a large number of the invasive plant species. For example, 50% of the 22 plant species occupied less than or equal to a maximum of 0.5 acres. In all likelihood, the actual cover for these species is considerably less than the maximum. Furthermore, each of these species was found in no more than 5.6% of search units, with the majority only found in a single year (i.e., either 2006 or 2011). The growth characteristics of many of these species allow plant-specific applications of chemicals with limited overspray. The following early detection species allow

high control selectivity because as woody plants, the stems may be cut and directly treated with herbicides: Chinaberry tree (*Melia azedarach*), multiflora rose (*Rosa multiflora*), and silktree (aka mimosa, *Albizia julibrissin*). The same is true for the vine Chinese wisteria (*Wisteria sinensis*). Finally, the clumped growth of giant reed, Nepalaese browntop, and sericea lespedeza (*Lespedeza cuneata*) limits the effect of overspray when treating these species. Depending on the location of these species, selectivity can also be increased through the use of a broadleaf-specific or grass-specific herbicides. The use of grass-specific herbicides near aquatic areas is often precluded under the law. Bald brome (*Bromus racemosus*) and barnyardgrass (*Echinochloa crus-galli*), on the other hand, are often difficult to target because they often grow closely among numerous other species in open fields.

Prospects for Control Based on Habitat

The most difficult invasive plant species to treat based on their habitats are abundant species that occur in the wetlands at Arkansas Post National Memorial. Common water hyacinth occurs as a floating and rooted aquatic plant throughout the waters surrounding the park. The rooted aquatic plants alligatorweed (approximately 6 in. water depths), wart-removing herb (approximately 3 in. water depths), and narrowleaf cattail (*Typha angustifolia*) occur along a gradient of decreasing water depth. Eastern baccharis (*Baccharis halimifolia*), a native, but sometimes weedy shrub in bottomland hardwood forests, grows in the driest portions of the wetlands. Common water hyacinth cannot reasonably be controlled given its extent in aquatic habitats throughout the Arkansas River. Alligatorweed and wart-removing herb can also not be treated without extensive damage to surrounding vegetation because they are so highly intermixed with other wetland species. The height of cattail and Eastern baccharis allows these plants to be treated without damaging surrounding plants. However, the extent of these species and the difficulty of working in wetlands may also preclude their treatment with herbicides.

Recommended Landscape Maintenance Treatments Related to Invasive Plants

Taken together, the analysis of biological considerations (see *Biological Considerations Affecting Invasive Plant Management Decisions*) and study of the cultural landscape report (see *Vegetation within the Cultural Landscape of Memorial Unit, Arkansas Post National Memorial*) lead us to the following landscape maintenance treatments at this time (Table 3). Our recommendations are generally summarized under section headings, many of which correspond with the scenarios outlined in Figure 1 and summarized in *Invasive Plant Management Scenarios in Cultural Landscapes*.

Maintenance of Invasive Plant Species as Cultural Resources

Japanese honeysuckle and common mullein (*Verbascum thapsus*) should not currently be treated due to their listing as potential ethnobotanical resources (Evans, unpublished list) and as cited in the cultural landscape report. The ethnographic importance of these species and potential replacement with alternative native plant species should be considered in the future.

Propagation of Invasive Plant Performing Valuable Service

Bermudagrass provides a turf for open park areas and should be controlled in areas beyond the intended areas of use. Bald brome and barnyard grass may also be treated outside of lawns.

Manual or Mechanical Control of Invasive Plant to Support Recreational Use

Water hyacinth is a floating or rooted aquatic plant capable of dominating entire water bodies. We recommend using manual or mechanical controls to remove these plants only within areas where the plant prohibits recreational activities such as boating and fishing. A biological control is available for water hyacinth and may be considered as warranted, especially as part of multi-jurisdictional control efforts.

Control of Invasive Plants to Protect the Cultural Landscape

The cultural landscape report (Quinn Evans 2005) identified hardy orange and privet as species that are becoming widespread and diminish the remnant historical character of the park. Cut-stump or basal bark treatments effectively control these species with little collateral damage to surrounding vegetation. As is current practice, we also recommend that the park continue to treat black locust (a species noted as having "high/medium" ecological impact) at the same time these other woody species are treated. The same control method can be used for efficiency.

Precautionary Control of Invasive Plants with Low Abundance and High Feasibility

Based on the abundance ($\leq$ 0.5 ac) and growth habit of these early detection species, we expect control of the following species to present few impacts to surrounding vegetation: Chinaberry tree, Chinese wisteria, giant reed, multiflora rose, Nepalaese browntop, sericea lespedeza, and silktree. Furthermore, controls will likely be effective with little damage to surrounding vegetation and are much more feasible now than following further spread. As state noxious weeds, barnyardgrass and Japanese brome should be controlled in areas outside of lawns.

Pro-Con Analyses

We recommend against treating invasive plants within the wetlands in Arkansas Post National Memorial. For alligator weed and wart-removing herb, treatment is largely impractical and would likely lead to extensive bare soil in the wetlands. While treatment is more feasible for eastern baccharis and narrowleaf cattail, we still do not recommend treatment for the following reasons. First, Eastern baccharis is native to some parts of Arkansas, although the plant may rapidly invade areas once it becomes established. As for cattail, we believe that chemical use in the wetlands is not warranted pending further study of the problem. However, such consideration should be made quickly given the "high/medium" ecological impact of the plant. A biological control is available for alligatorweed and may be considered as warranted.

We recommend against controlling Japanese honeysuckle because it is currently widespread within the park. The plant's vining growth habit also makes control difficult. In the future, the the park and EPMT may evaluate the feasibility of controlling the plant within the park. Consultation with the park's cultural anthropologist may identify control measures that are sensitive to the plant's potential ethnographic value.

We recommend treating Johnsongrass based on our observation that it may be increasing in abundance, its relatively low abundance, and its designation as a state noxious weed. Treatments can be highly targeted using a backpack sprayer or portable pump to limit unintended damage to surrounding vegetation.

Periwinkle has been controlled on a limited basis as part of a small-scale study for treatment effectiveness. Our observation is that the preferred treatment is annual foliar applications of triclopyr during the growing season or during warm winter days.

Literature Cited

Birnbaum, C.A. 1994. Protecting cultural landscapes: planning treatment and management of historic landscapes (National Park Service Preservation Brief 36). Available from http://www.nps.gov/hps/tps/briefs/brief36.htm (accessed 16 March 2012).

Evans, M.J. 2009. Applied ethnography and park management at Pipestone National Monument. The George Wright Forum 26: 80-84.

Evans M.J. Plant list with tribal affiliations. National Park Service unpublished report, Omaha, Nebraska.

Executive Order 13112. Available from http://www.invasivespeciesinfo.gov/laws/execorder.shtml (accessed 16 march 2012).

National Park Service. 2006. Management Policies 2006. National Park Service unpublished report, Washington, D.C. Available Executive Order 13112. Available from http://www.nps.gov/policy/mp2006.pdf (accessed 16 march 2012).

NPSpecies - The National Park Service Biodiversity Database. IRMA version. https://irma.nps.gov/Species.mvc/Welcome (accessed 16 February 2012).

Quinn Evans Architects. 2005. Arkansas Post National Memorial: Cultural landscape report. National Park Service unpublished report, Omaha, Nebraska.

Young, C.C., J.L. Haack, L.W. Morrison, and M.D. DeBacker. 2007. Invasive exotic plant monitoring protocol for the Heartland Inventory and Monitoring Program. Natural Resource Report NPS/HTLN/NRR-2007/018. National Park Service, Fort Collins, Colorado.

Figure 2. Invasive exotic plant search units in Arkansas Post National Memorial – Main Unit. The search units indicate the search locations for invasive exotic plants in 2006 and 2011.

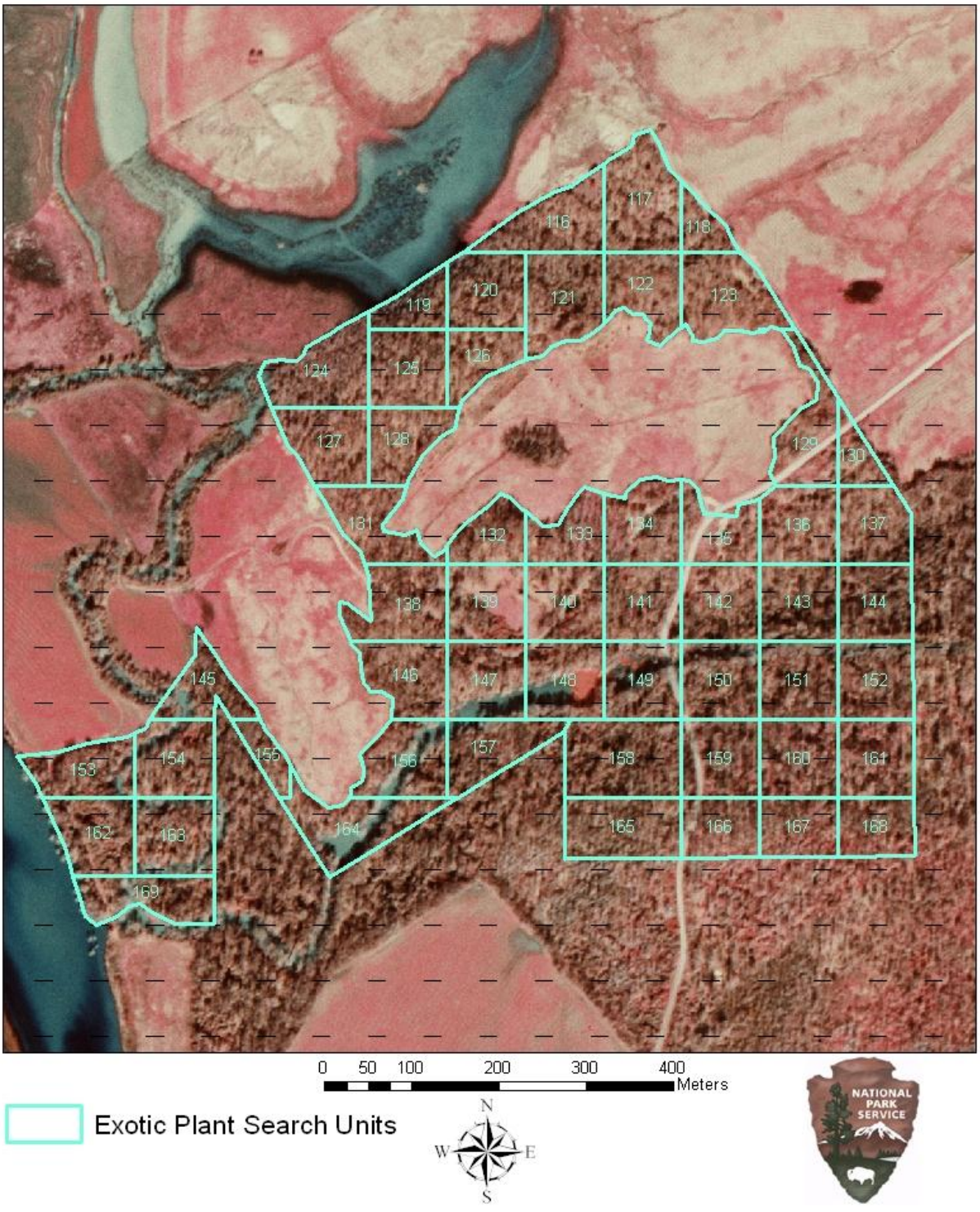

Figure 3. Invasive exotic plant search units in Arkansas Post National Memorial – Osotouy Unit. The search units indicate the search locations for invasive exotic plants in 2006 and 2011.

Table 1. Watch lists for invasive exotic plant species sought during monitoring at Arkansas Post National Memorial.

Early Detection Watch List		Park-Established Watch List		Park Based Watch List	
Ailanthus altissima	Tree of heaven	*Albizia julibrissin*	Silktree	*Bromus japonica*	Japanese brome
Alliaria petiolata	Garlic mustard	*Alternanthera philoxeroides*	Alligatorweed	*Lolium perenne*	Perennial ryegrass
Alternanthera sessilis	Sessile joyweed	*Baccharis halimifolia*	Eastern baccharis (NATIVE)	*Paspalum urvillei*	Vasey's grass
Ampelopsis brevipedunculata	Amur peppervine	*Cynodon dactylon*	Bermudagrass	*Torilis japonica*	Japanese hedgeparsley
Arctium minus	Lesser burdock	*Echinochloa crus-galli*	Barnyardgrass		
Arundo donax	Giant reed	*Ligustrum sinense*	Chinese privet		
Bothriochloa bladhii	Caucasian bluestem	*Ligustrum vulgare*	European privet		
Bromus inermis	Smooth brome	*Lonicera japonica*	Japanese honeysuckle		
Bromus racemosus	Bald brome	*Poncirus trifoliata*	Hardy orange		
Bromus sterilis	Poverty brome	*Populus alba*	White poplar		
Bromus tectorum	Cheatgrass	*Robinia pseudoacacia*	Black locust		
Carduus nutans	Nodding plumeless thistle	*Rumex acetosella*	Common sheep sorrel		
Celastrus orbiculatus	Oriental bittersweet	*Rumex crispus*	Curly dock		
Centaurea stoebe ssp. micranthos	Spotted knapweed	*Sorghum halepense*	Johnsongrass		
Cirsium arvense	Canada thistle	*Torilis arvensis*	Spreading hedgeparsley		
Cirsium vulgare	Bull thistle	*Verbascum thapsus*	Common mullein		
Coronilla varia	Crownvetch	*Vinca major*	Bigleaf periwinkle		
Daucus carota	Queen Anne's lace	*Wisteria sinensis*	Chinese wisteria		
Dioscorea oppositifolia	Chinese yam				
Dipsacus fullonum	Fuller's tasel				
Egeria densa	Brazilian waterweed				
Eichhornia crassipes	Common water hyacinth				
Elaeagnus pungens	Thorny olive				
Elaeagnus umbellata	Autumn olive				
Elaeagnus umbellata/angustifolia	Russian olive				
Elymus repens	Quackgrass				
Eragrostis curvula	Weeping lovegrass				
Euonymus fortunei	Winter creeper				
Euphorbia cyparissias	Cypress spurge				
Glechoma hederacea	Ground ivy				
Hedera helix	English ivy				
Hemerocallis fulva	Orange daylily				

Table 1. (continued)

Early Detection Watch List		Park-Established Watch List	Park Based Watch List
Hesperis matronalis	Dames rocket		
Holcus lanatus	Common velvetgrass		
Humulus japonicus	Japanese hop		
Hydrilla verticillata	Waterthyme		
Hypericum perforatum	Common St. Johnswort		
Imperata cylindrica	Cogongrass		
Iris pseudacorus	Paleyellow iris		
Leonurus cardiaca	Common motherwort		
Lespedeza bicolor	Shrub lespedeza		
Lespedeza cuneata	Sericea lespedeza		
Ligustrum lucidum	Glossy privet		
Linaria vulgaris	Butter and eggs		
Lolium arundinaceum	Tall fescue		
Lolium pratense	Meadow fescue		
Lolium spp	Fescue		
Lonicera maackii	Amur honeysuckle		
Lonicera morrowii	Morrow's honeysuckle		
Lotus corniculatus	Bird's-foot trefoil		
Lygodium japonicum	Japanese climbing fern		
Lysimachia nummularia	Creeping jenny		
Lythrum salicaria	Purple loosestrife		
Melia azedarach	Chinaberrytree		
Melilotus officinalis	Sweetclover		
Microstegium vimineum	Nepalese browntop		
Morus alba	White mulberry		
Murdannia keisak	Wartremoving herb		
Myosotis scorpioides	True forget-me-not		
Myriophyllum aquaticum	Parrot feather watermilfoil		
Myriophyllum spicatum	Eurasian watermilfoil		
Najas minor	Brittle waternymph		

Table 1. (continued)

Early Detection Watch List		Park-Established Watch List	Park Based Watch List
Nandina domestica	Sacred bamboo		
Pastinaca sativa	Wild parsnip		
Paulownia tomentosa	Princesstree		
Phalaris arundinacea	Reed's canarygrass		
Photinia serratifolia	Taiwanese photinia		
Phragmites australis	Common reed		
Phyllostachys spp			
Poa compressa	Canada bluegrass		
Poa pratensis	Kentucky bluegrass		
Polygonum cuspidatum	Japanese knotweed		
Potamogeton crispus	Curly pondweed		
Potentilla recta	Sulphur cinqefoil		
Prunus mahaleb	Mahaleb's cherry		
Pueraria montana var. lobata	Kudzu		
Pyrus calleryana	Callery's pear		
Rhamnus cathartica	Common buckthorn		
Rorippa nasturtium-aquaticum	Watercress		
Rosa multiflora	Multiflora rose		
Salvinia molesta	Kariba-weed		
Saponaria officinalis	Bouncingbet		
Solanum viarum	Tropical soda apple		
Sphenoclea zeylanica	Chickenspike		
Tamarix ramosissima	Saltcedar		
Tanacetum vulgare	Common tansy		
Torilis arvensis	Spreading hedgeparsley		
Triadica sebifera	Chinese tallow		
Typha angustifolia	Narrowleaf cattail		
Typha X glauca			
Ulmus pumila	Siberian elm		
Vinca minor	Common periwinkle		
Wisteria floribunda	Japanese wisteria		

Table 2. Overview of invasive exotic plants found in Arkansas Post National Memorial. Ecological impact and general management difficulty based on NatureServe I-Rank subranks (Morse et al. 2004). Subranks are given as high (H), medium (M), low (L), insignificant (I), unknown (U), a range of ranks (indicated by /), or not available (--).

Scientific Name	Common Name	Watch list	2006 Park-wide cover (acres)	2011 Park-wide cover (acres)	2006 Frequency (%)	2011 Frequency (%) (Frequency difference 2006-2011)	Ecological impact	Management difficulty
Poncirus trifoliata	Hardy orange	Park Established	4.5-82.7	0.2-3.5	62.6	49.5(-13.1)	----	----
Lonicera japonica	Japanese honeysuckle	Park Established	1.1-18.7	0.3-6.5	92.5	69.2(-23.3)	M	HM
Typha angustifolia	Narrowleaf cattail	Early Detection	0.6-6.8	0.2-3.0	7.5	8.4(0.9)	HM	M
Ligustrum sinense	Chinese privet	Park Established	0.5-7.9	0.1-3.0	60.7	54.2(-6.5)	M	L
Eichhornia crassipes	Common water hyacinth	Early Detection	0.5-5.7	0.9-10.9	7.5	14.0(6.5)	HM	H
Sorghum halepense	Johnsongrass	Park Established	0.1-2.0	0.7-14.1	9.3	7.5(-1.8)	ML	HM
Vinca major	Bigleaf periwinkle	Park Established	1.0-1.6	0.4-3.0	2.8	3.7(0.9)	ML	M
Baccharis halimifolia	Eastern baccharis	Park Established	0.08-1.4	0.1-2.3	15.0	10.3(-4.7)	----	----
Robinia pseudoacacia	Blacklocust	Park Established	0.03-0.7	0.07-0.8	10.3	11.2(0.9)	HM	M
Cynodon dactylon	Bermudagrass	Park Established	0.03-0.3	0.9-11.3	0.9	33.6(32.7)	ML	HM
Microstegium vimineum	Nepalese browntop	Early Detection	0.01-0.3	0.03-0.5	4.7	4.7(0)	M	HM
Murdannia keisak	Wartremoving herb	Early Detection	0.009-0.2	0	4.7	0(-4.7)	M	U
Alternanthera philoxeroides	Alligatorweed	Park Established	0.007-0.3	0.1-2.2	12.1	13.1(1)	HM	M
Melia azedarach	Chinaberrytree	Early Detection	0.007-0.2	0.001-0.03	2.8	0.9(-1.9)	ML	ML
Albizia julibrissin	Silktree	Park Established	0.001-0.03	0.006-0.1	5.6	0.9(-4.7)	ML	ML
Bromus racemosus	Bald brome	Early Detection	0.001-0.03	0	1.9	0(-1.9)	MI	U
Lespedeza cuneata	Sericea lespedeza	Early Detection	0.001-0.03	0	1.9	0(-1.9)	ML	ML

Table 2. (continued)

Scientific Name	Common Name	Watch list	2006 Park-wide cover (acres)	2011 Park-wide cover (acres)	2006 Frequency (%)	2011 Frequency (%) (Frequency difference 2006-2011)	Ecological impact	Management difficulty
Rosa multiflora	Multiflora rose	Early Detection	0.001-0.03	0	2.8	0(-2.8)	L	L
Torilis japonica	Erect hedgeparsley	Park Based	0.001-0.03	0	1.9	0(-1.9)	----	----
Paspalum urvillei	Vasey's grass	Park Based	0.0001-0.002	0	0.9	0(-0.9)	----	----
Verbascum thapsus	Common mullein	Park Established	0.0001-0.002	0.001-0.03	0.9	0.9(0)	ML	L
Bromus japonicus	Japanese brome	Park Based	0	0.03-0.3	0	1.9(1.9)	----	----
Wisteria sinensis	Chinese wisteria	Park Established	0	0.01-0.3	0	2.8(2.8)	ML	L
Arundo donax	Giant reed	Early Detection	0	0.006-0.1	0	0.9(0.9)	H	L
Echinochloa crus-galli	Barnyardgrass	Park Established	0	0.001-0.03	0	0.9(0.9)	LI	U
Lolium perenne	Perennial ryegrass	Park Based	0	0.001-0.03	0	0.9(0.9)	M	MI

Table 3. Treatment recommendations for invasive exotic plants in Arkansas Post National Memorial, Memorial Unit.

Common Name	Treatment Recommendation
Alligatorweed	Do not treat due to location in wetlands. Consider need for biological control.
Bald brome	Spot treat isolated clumps with glyphosate or imazapic in areas outside of lawns.
Barnyardgrass	Spot treat isolated clumps with glyphosate or imazapic in areas outside of lawns.
Bermudagrass	Do not treat except for outside of service areas. Use glyphosate or sethoxydim if needed.
Bigleaf periwinkle	Foliar treatment using triclopyr + a non-ionic surfactant.
Black locust	Cut stump treatment using triclopyr or imazapyr.
Chinaberrytree	Cut stump treatment using triclopyr or imazapyr.
Chinese privet	Cut stump treatment using triclopyr or imazapyr.
Chinese wisteria	Cut stump treatment using triclopyr or imazapyr.
Common mullein	Do not treat as may be ethnographic resource.
Common water hyacinth	Manual or mechanical only as needed to provide fishing and boating opportunities. Consider need for biological control.
Eastern baccharis	Do not treat due to location in wetlands.
Giant reed	Foliar treatment with aquatic-safe glyphosate.
Hardy orange	Cut stump treatment using triclopyr or imazapyr.
Japanese honeysuckle	Do not treat pending further evaluation of control feasibility.
Johnsongrass	Foliar treatment with glyphosate or imazapic.
Multiflora rose	Cut stump or foliar treatment with treatment with triclopyr or glyphosate.
Narrowleaf cattail	Do not treat due to location in wetlands. Requires additional prompt cost-benefit consideration.
Nepalese browntop	Treatment with aquatic-safe glyphosate or sethoxydim depending on proximity to water.
Sericea lespedeza	Foliar treatment using fluroxopyr.
Silktree	Cut stump treatment using triclopyr or imazapyr.
Wart-removing herb	Do not treat due to location in wetlands.

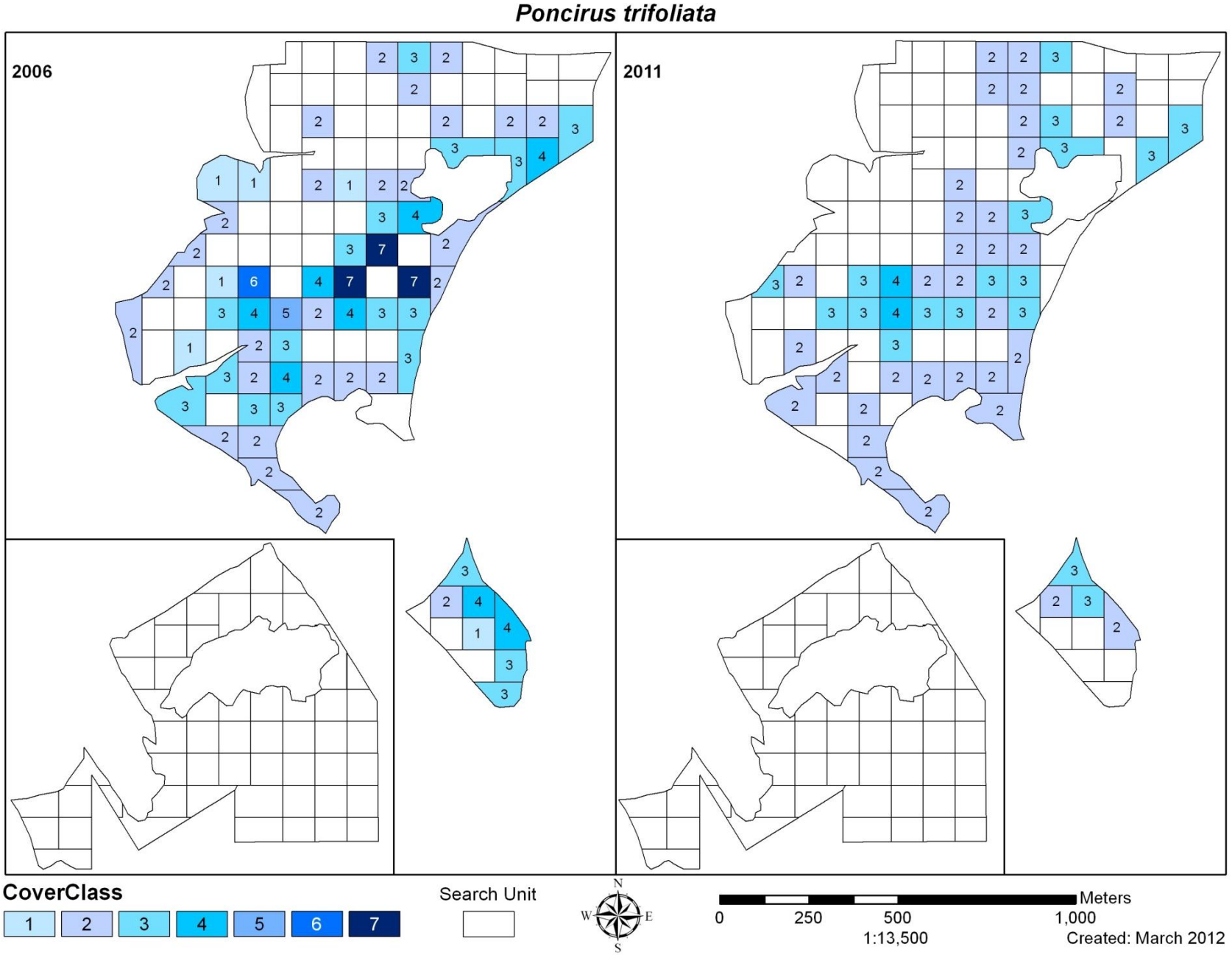

Figure 4. Abundance and distribution of *Poncirus trifoliata* (hardy orange) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

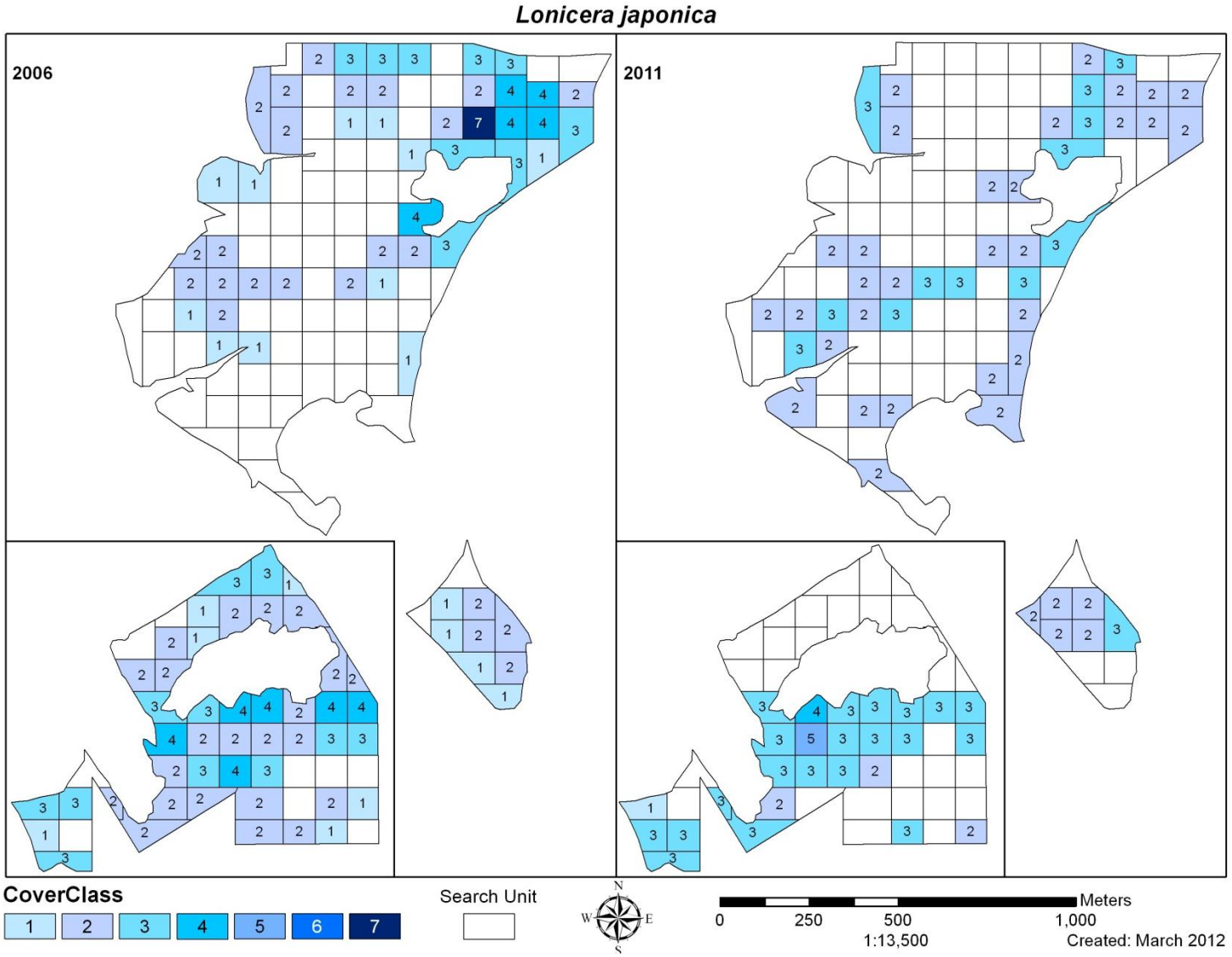

Figure 5. Abundance and distribution of *Lonicera japonica* (Japanese honeysuckle) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

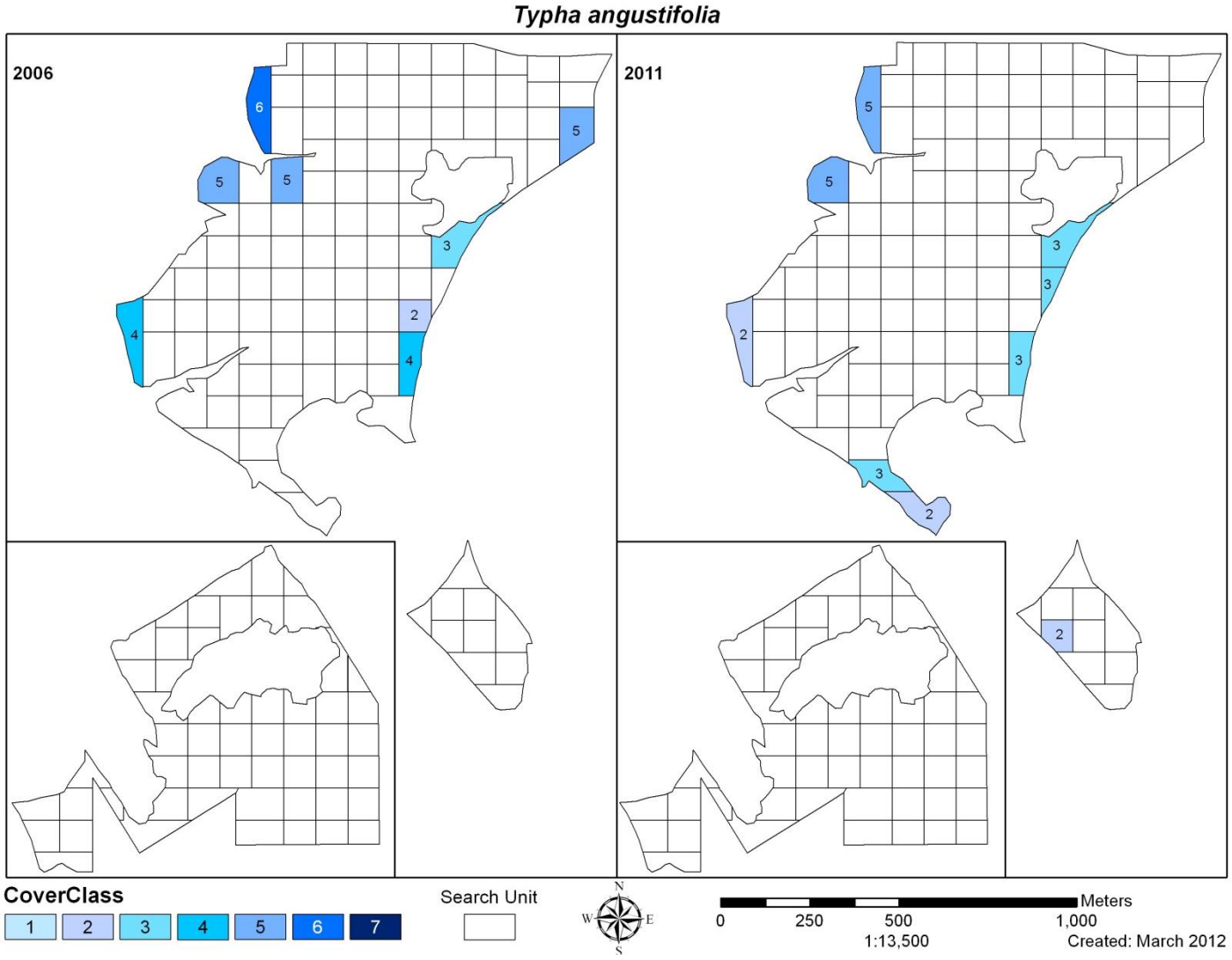

Figure 6. Abundance and distribution of *Typha angustifolia* (narrowleaf cattail) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

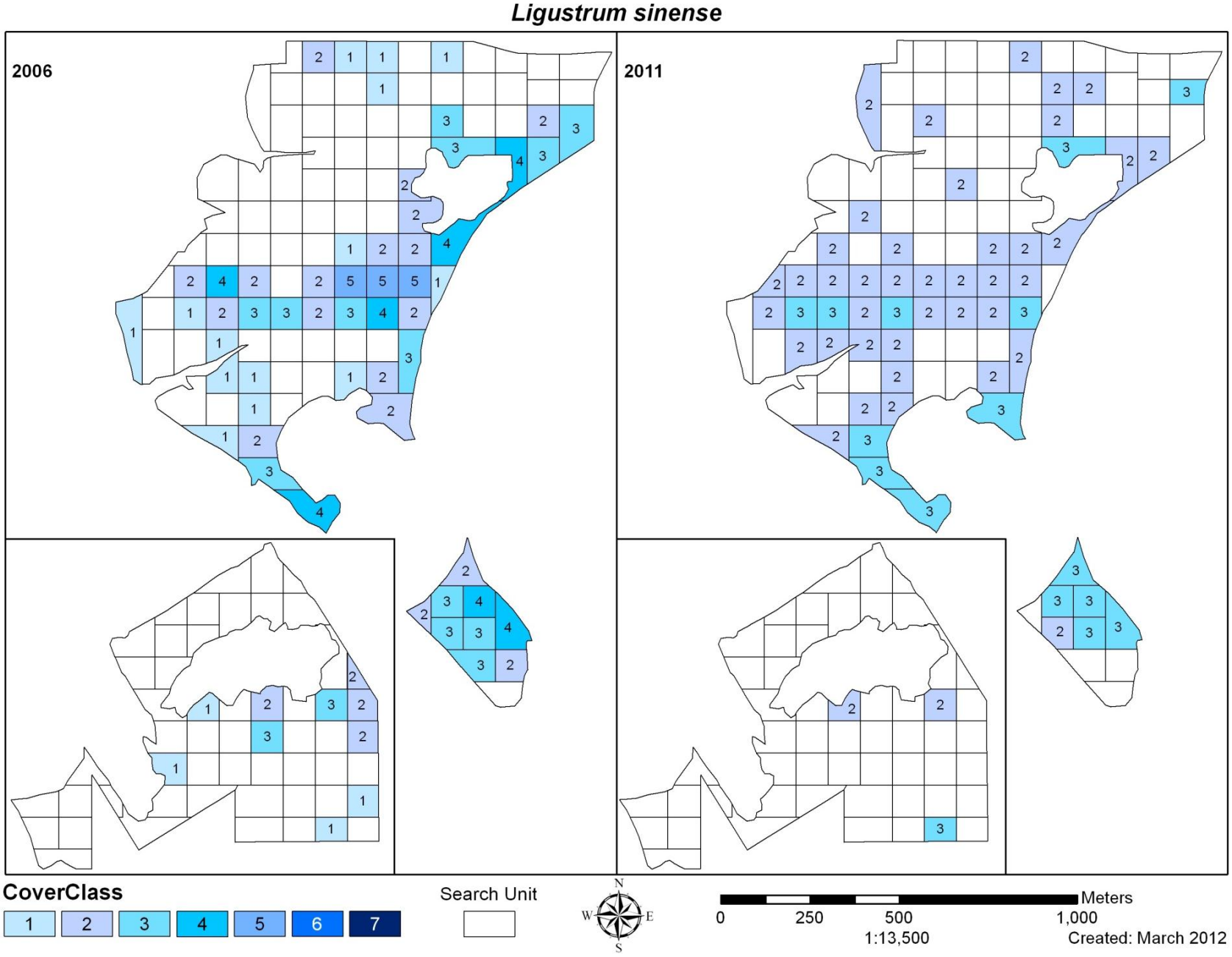

Figure 7. Abundance and distribution of *Ligustrum sinense* (Chinese privet) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

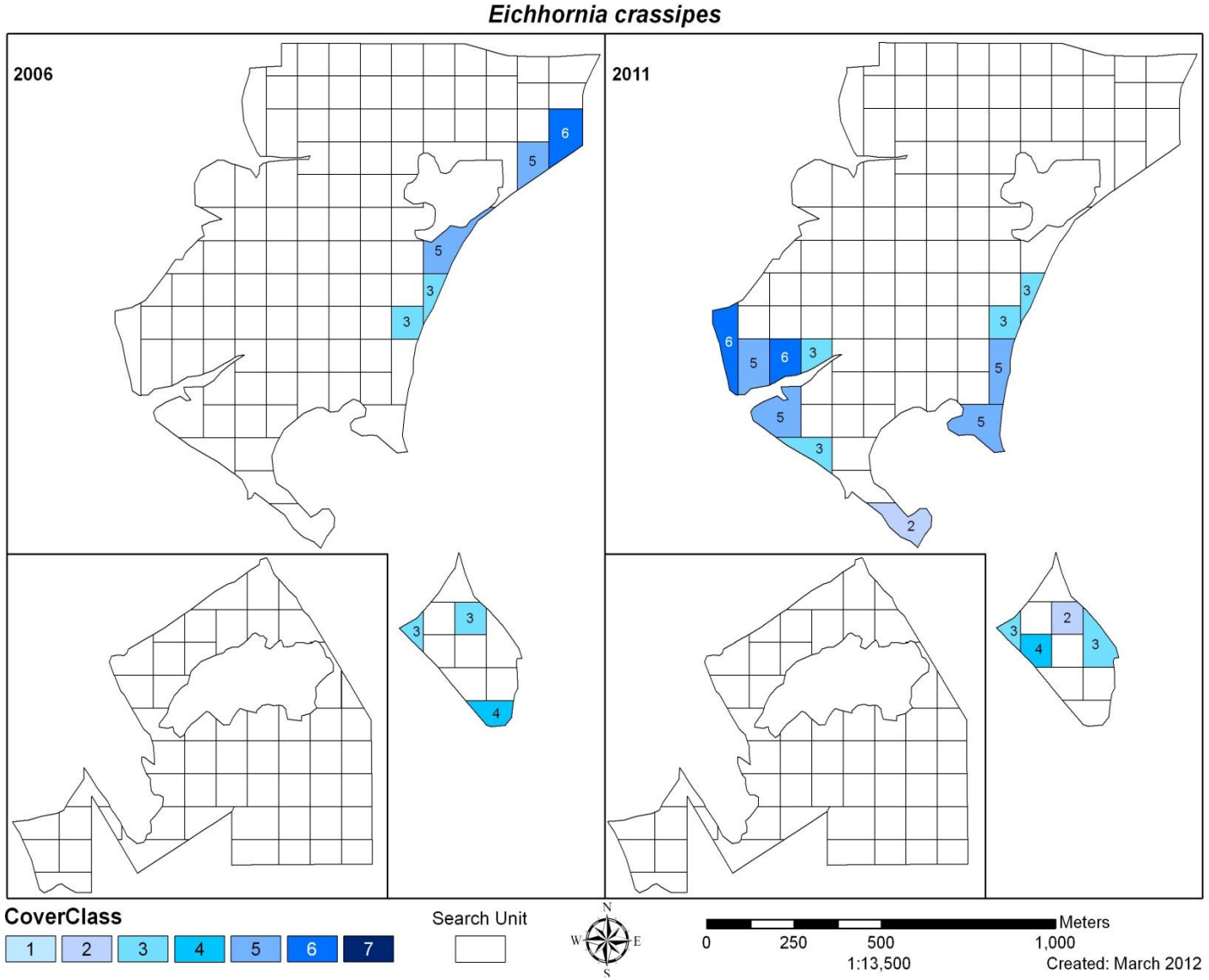

Figure 8. Abundance and distribution of *Eichornia crassipes* (common water hyacinth) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

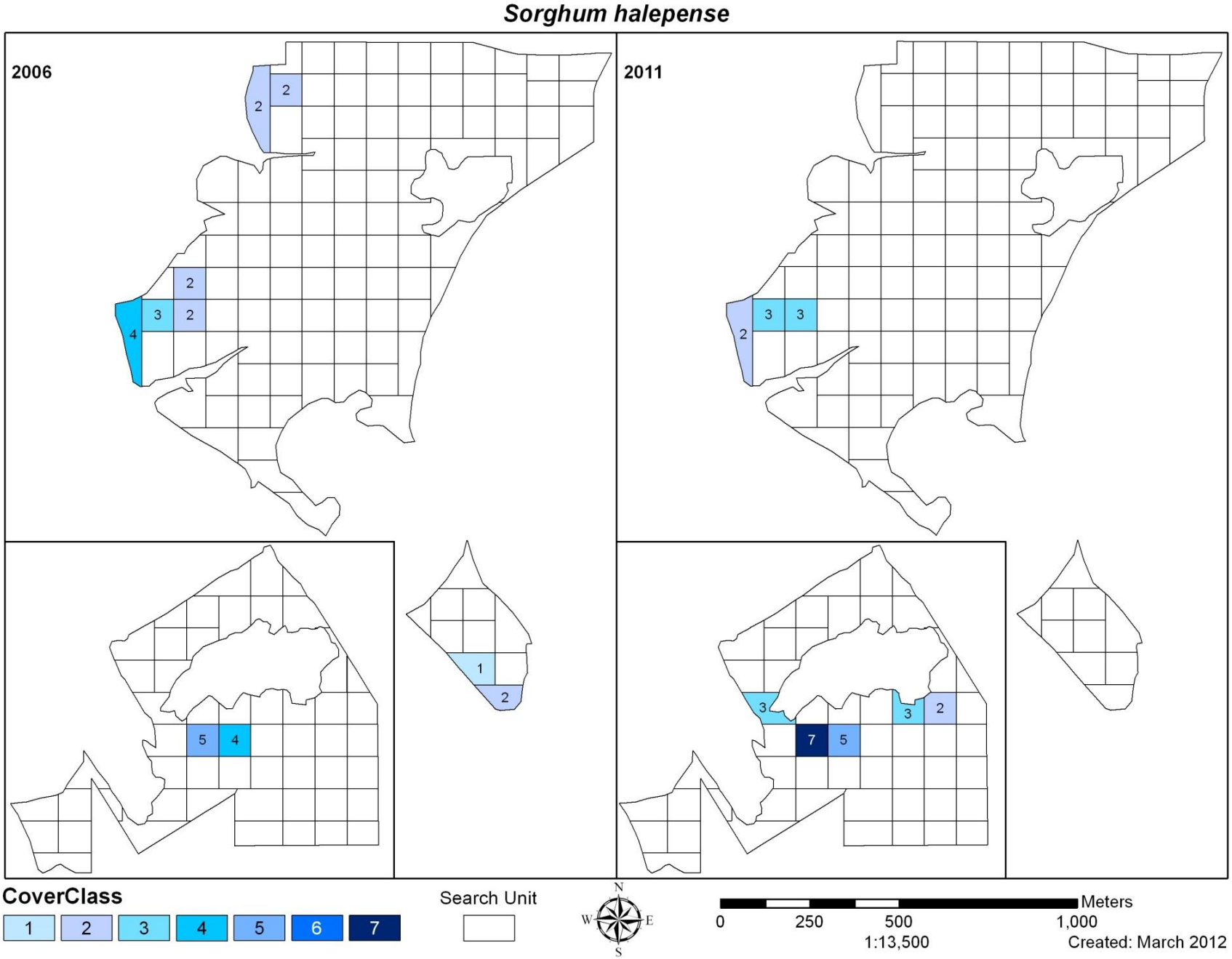

Figure 9. Abundance and distribution of *Sorghum halepense* (Johnsongrass) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

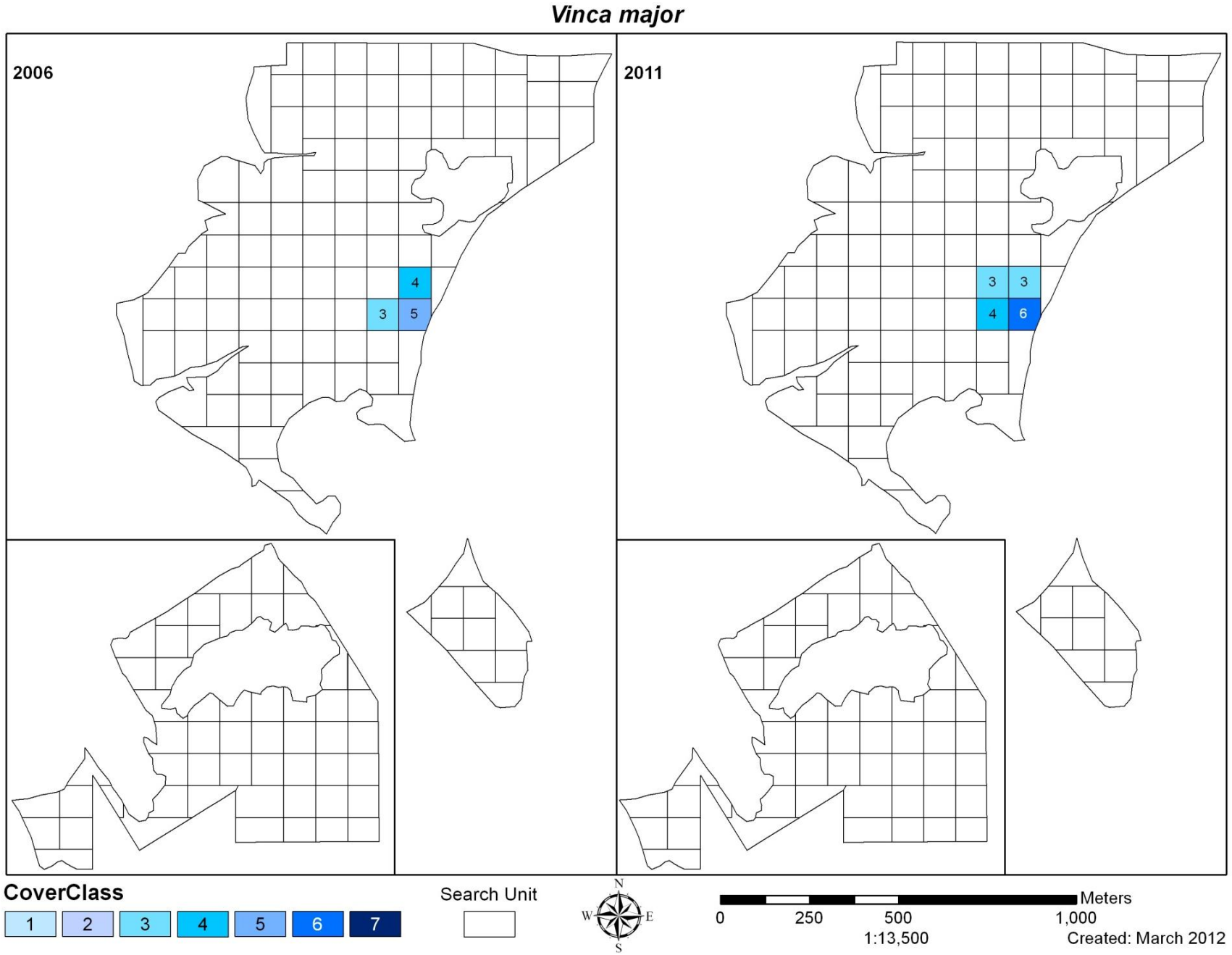

Figure 10. Abundance and distribution of *Vinca major* (bigleaf periwinkle) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

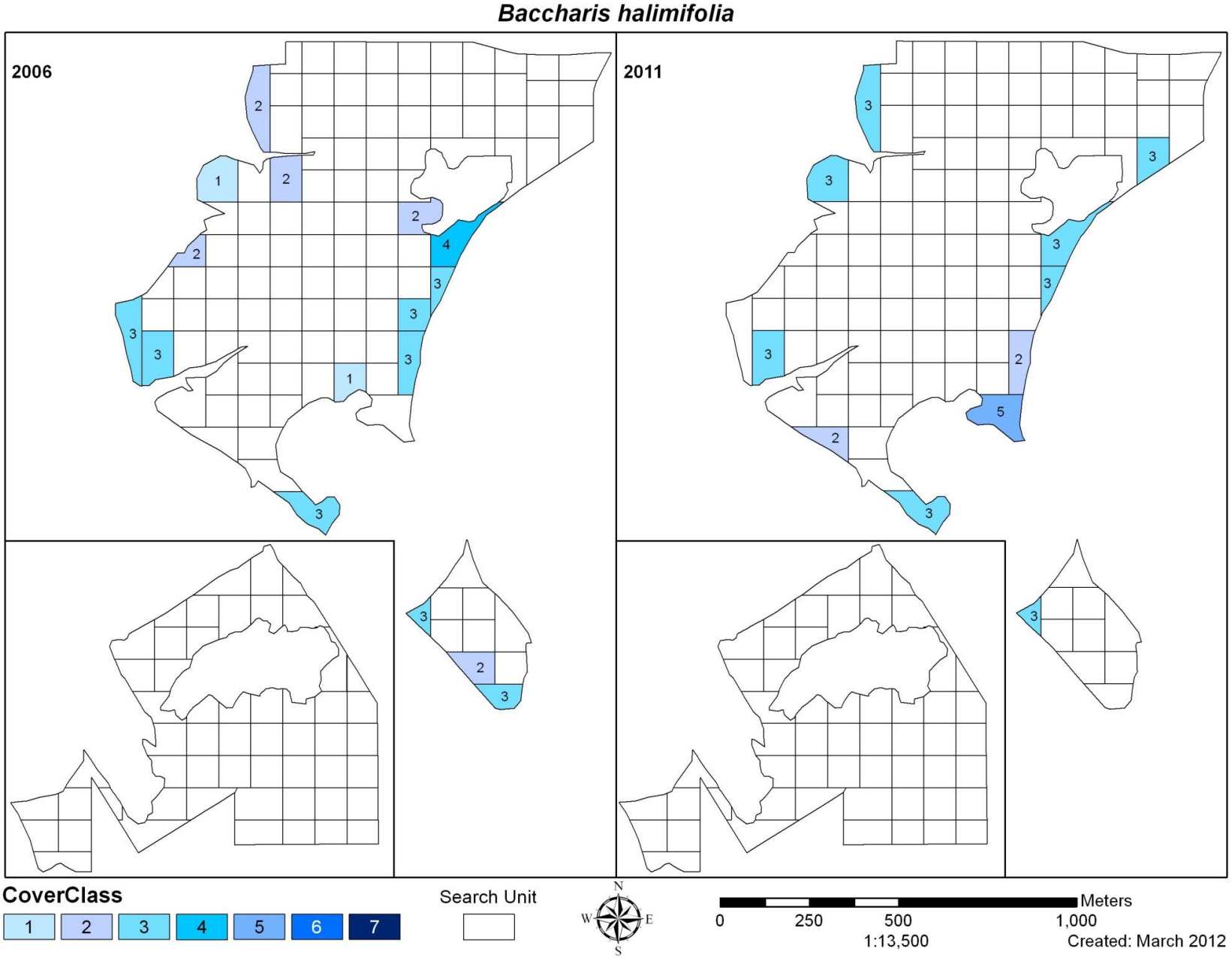

Figure 11. Abundance and distribution of Baccharis halimifolia (eastern baccharis) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

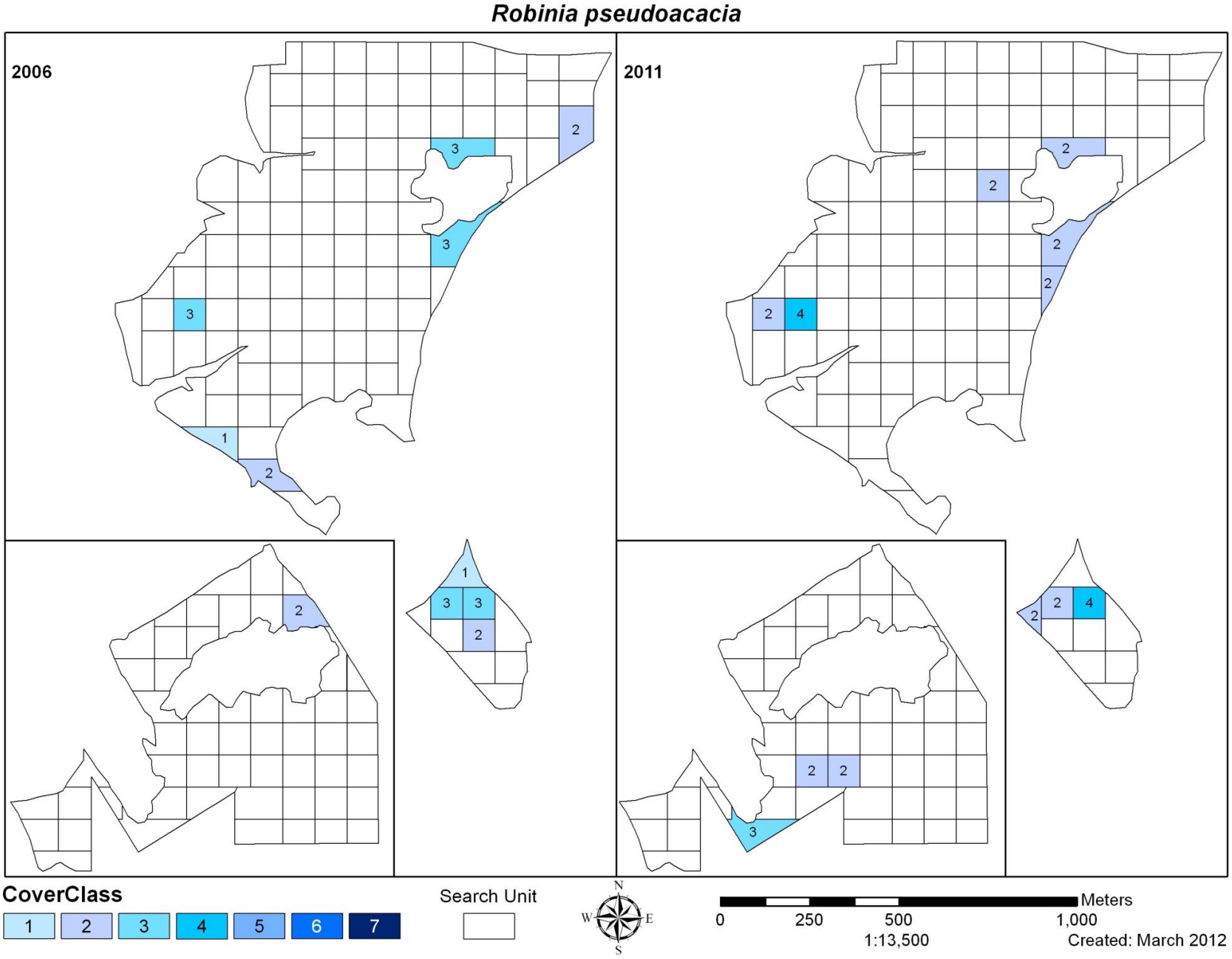

Figure 12. Abundance and distribution of *Robinia pseudoacacia* (black locust) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

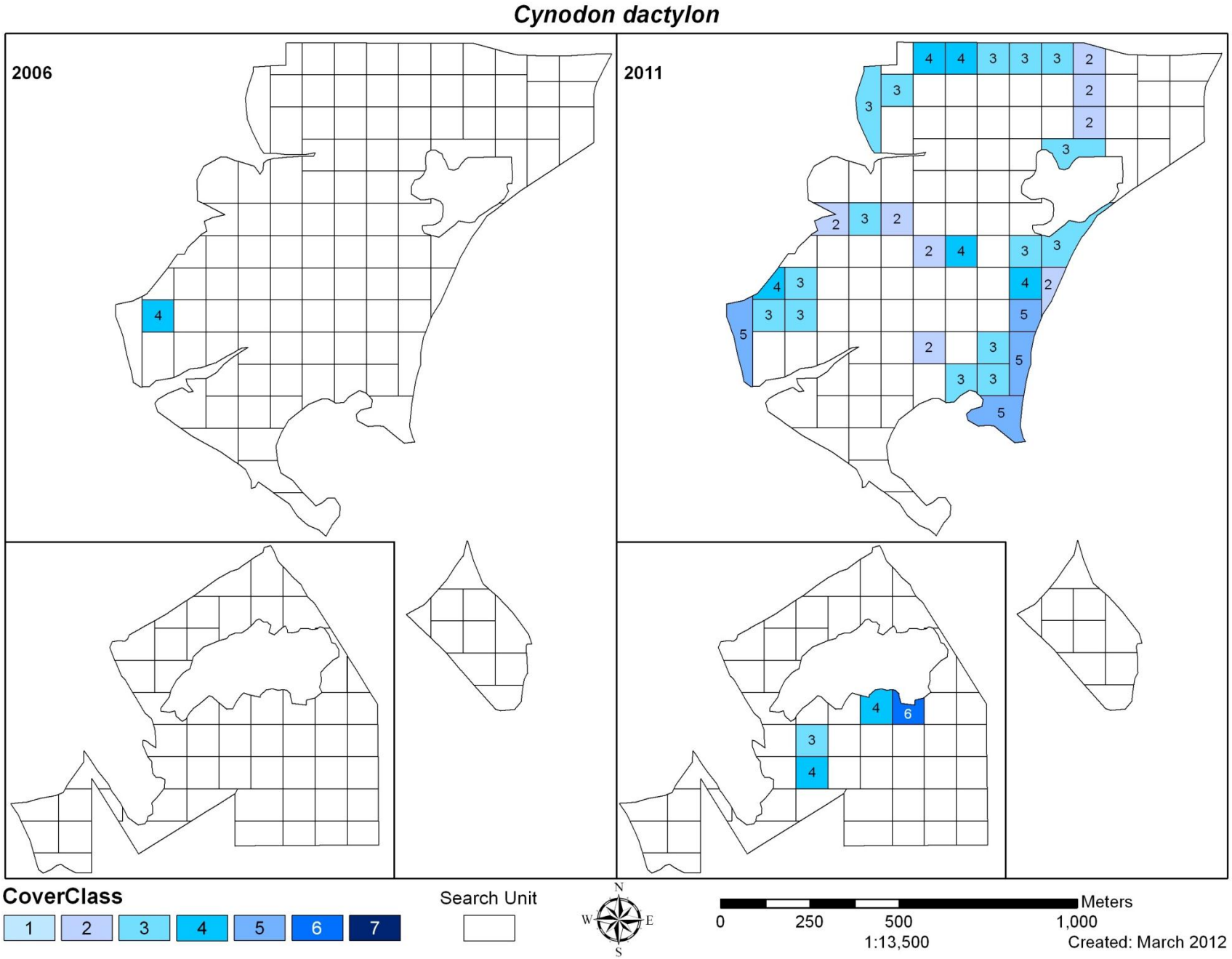

Figure 13. Abundance and distribution of *Cynodon dactylon* (bermudagrass) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

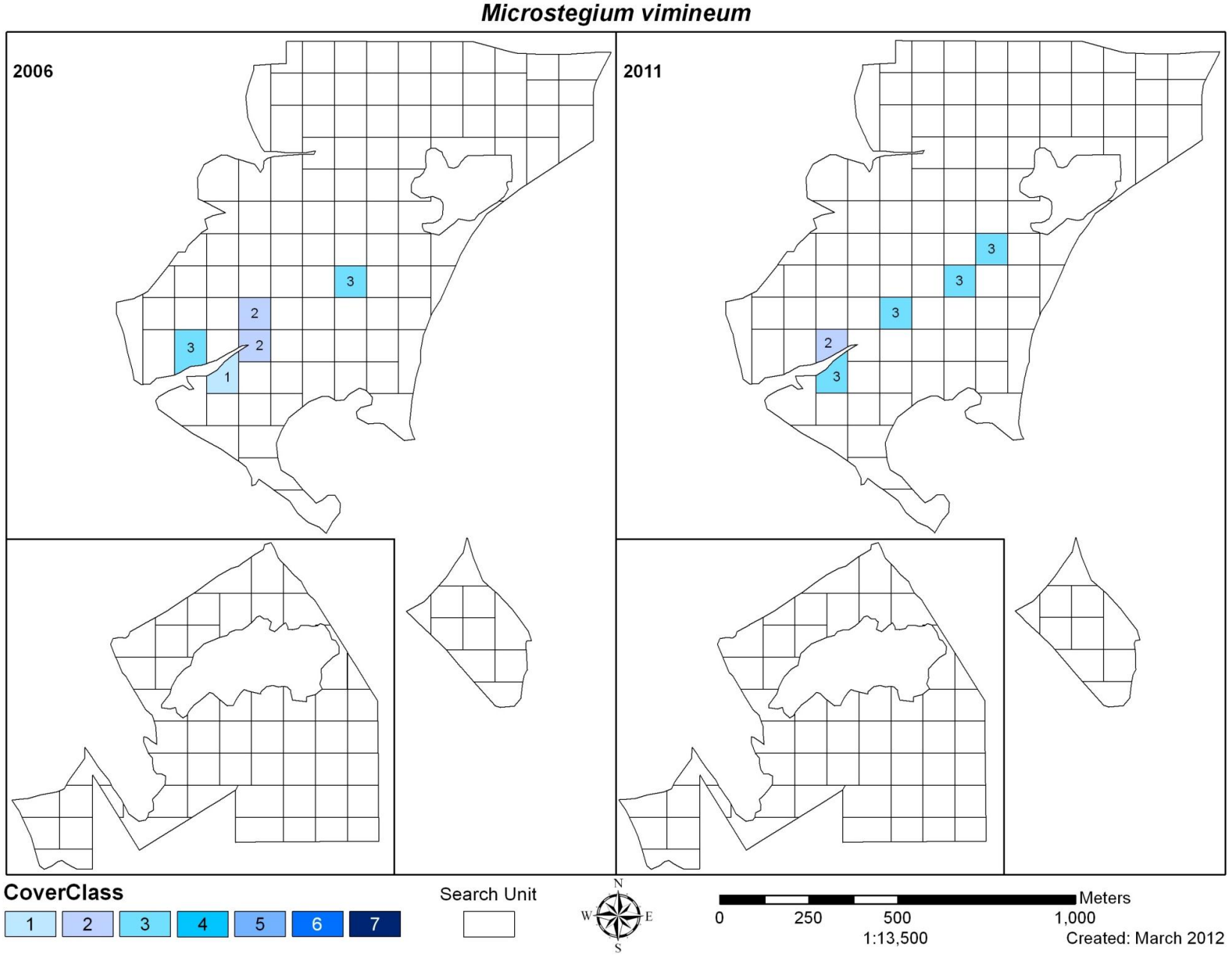

Figure 14. Abundance and distribution of *Microstegium vimineum* (Nepalese browntop) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

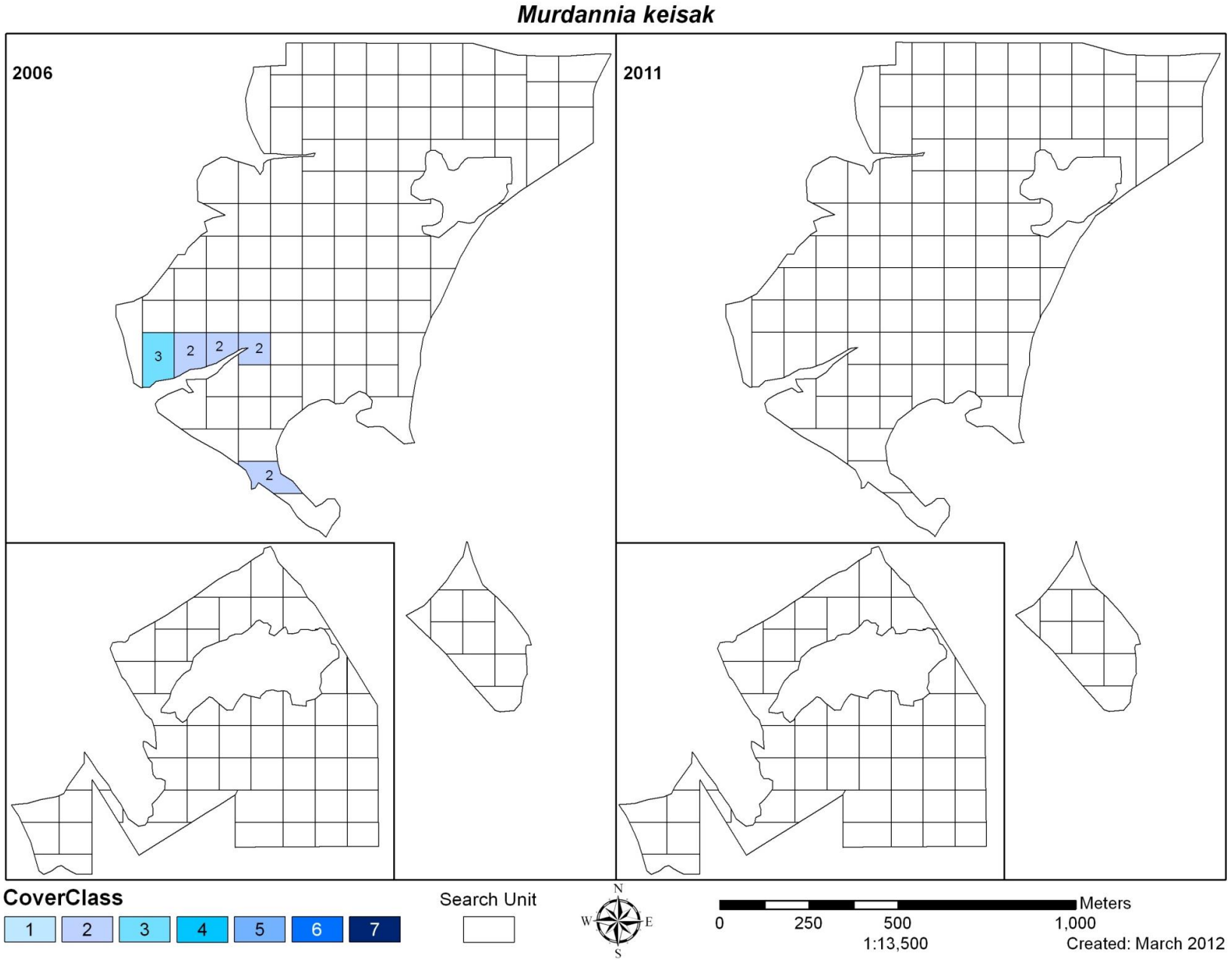

Figure 15. Abundance and distribution of *Murdannia keisak* (wart-removing herb) at Arkansas Post National Memorial, 2006 and 2011 Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

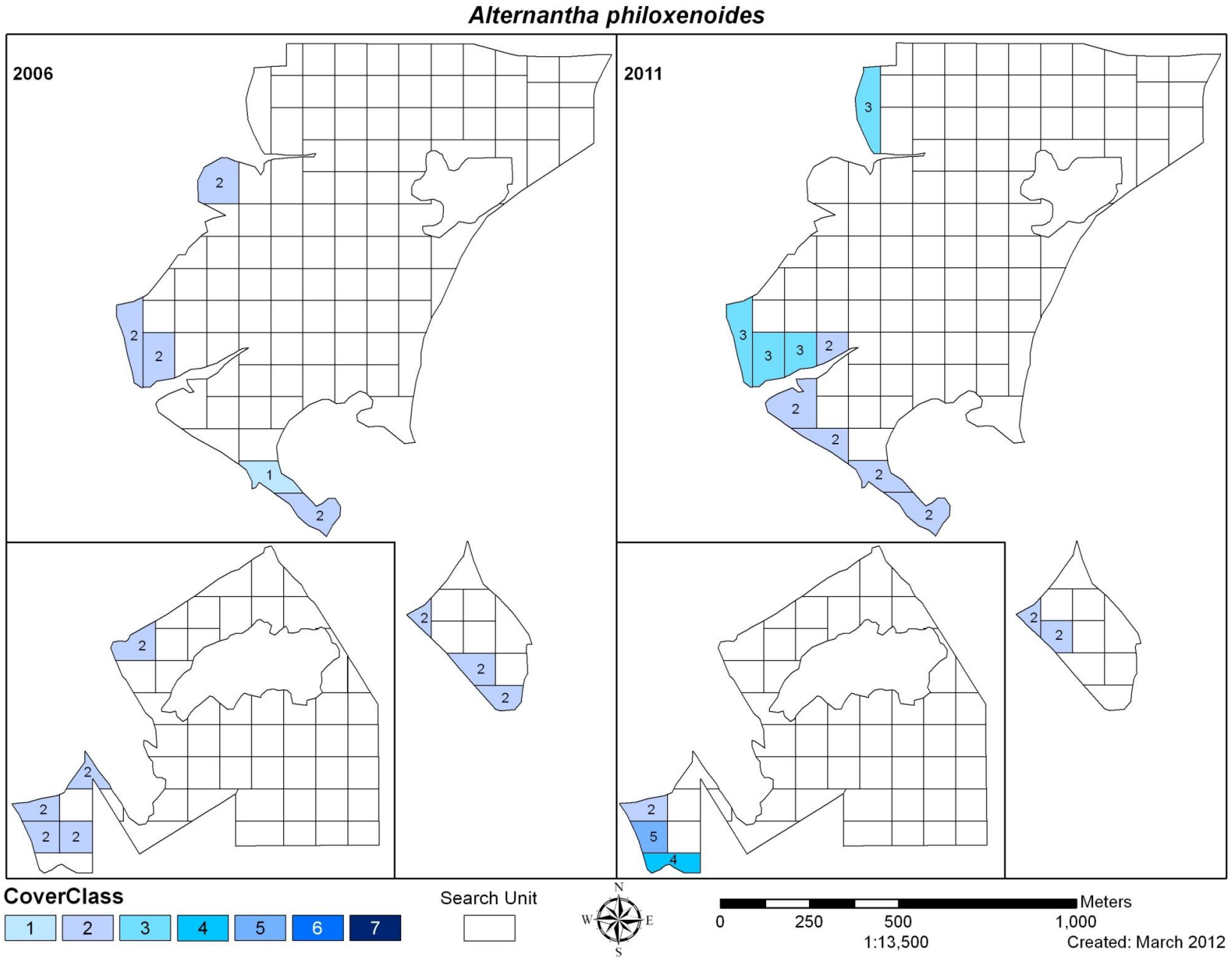

Figure 16. Abundance and distribution of *Alternanthera philoxeroides* (alligatorweed) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

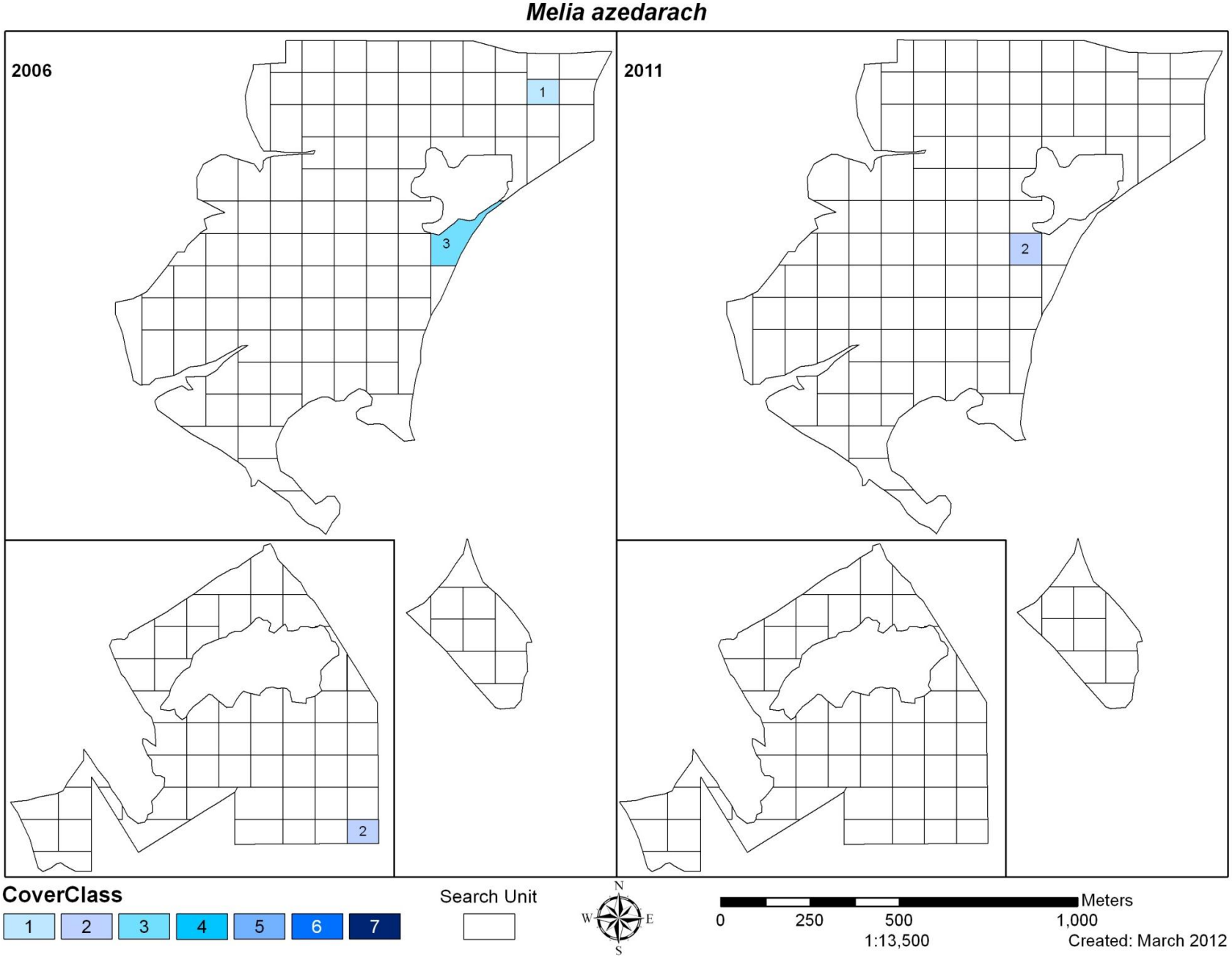

Figure 17. Abundance and distribution of *Melia azedarach* (Chinaberry tree) at Arkansas Post National Memorial, 2006 and 2011 Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

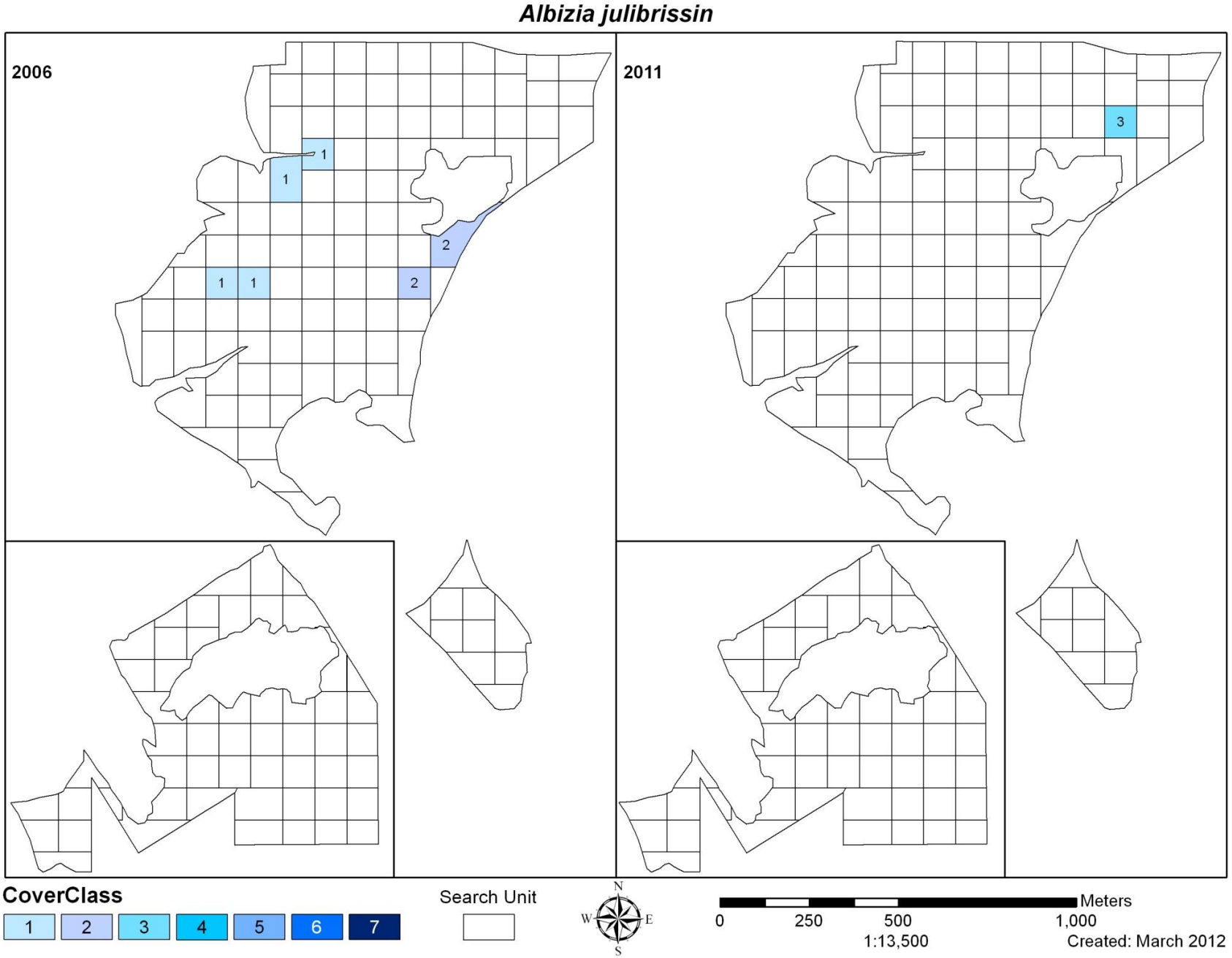

Figure 18. Abundance and distribution of *Albizia julibrissin* (silktree) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

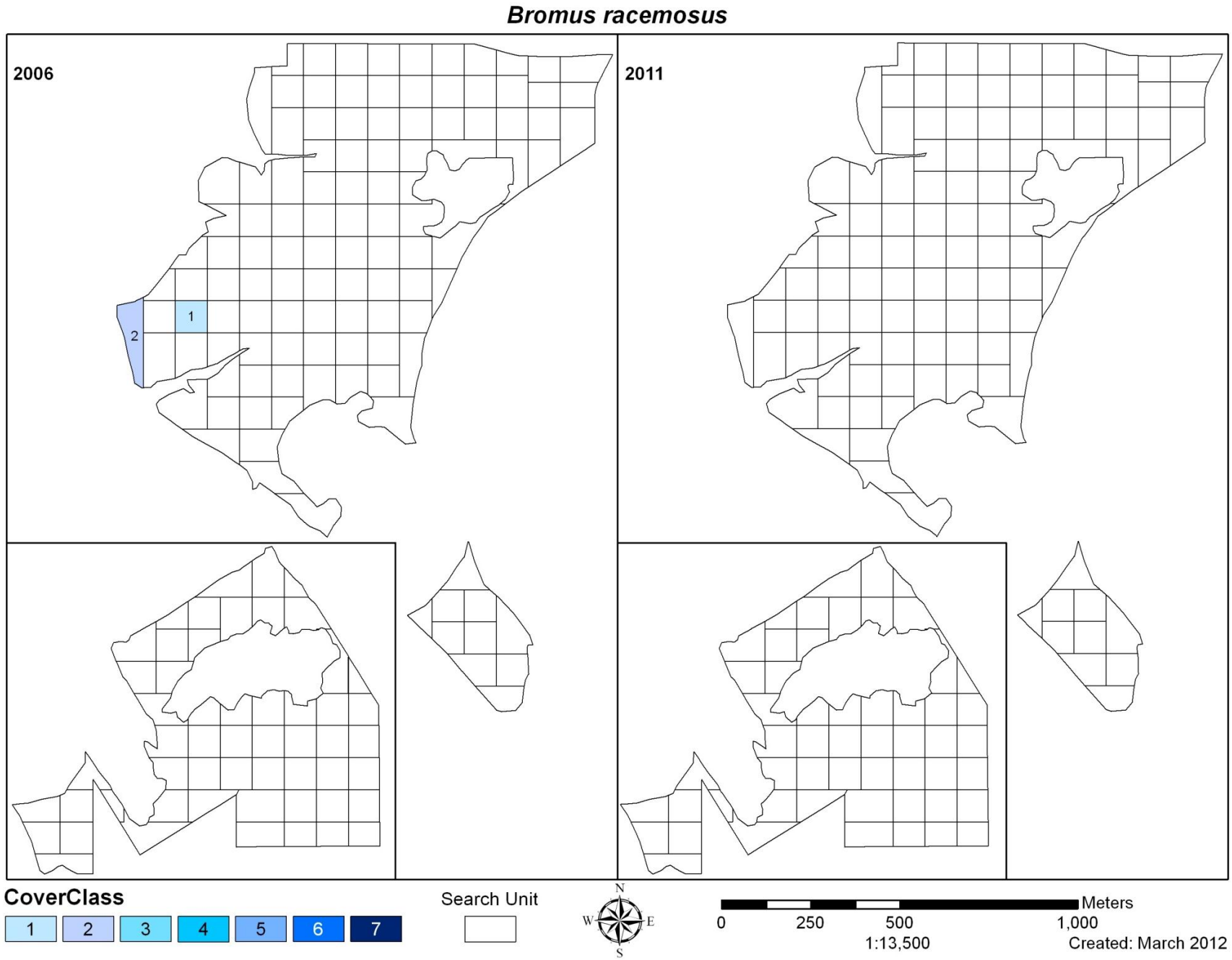

Figure 19. Abundance and distribution of *Bromus racemosus* (bald brome) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

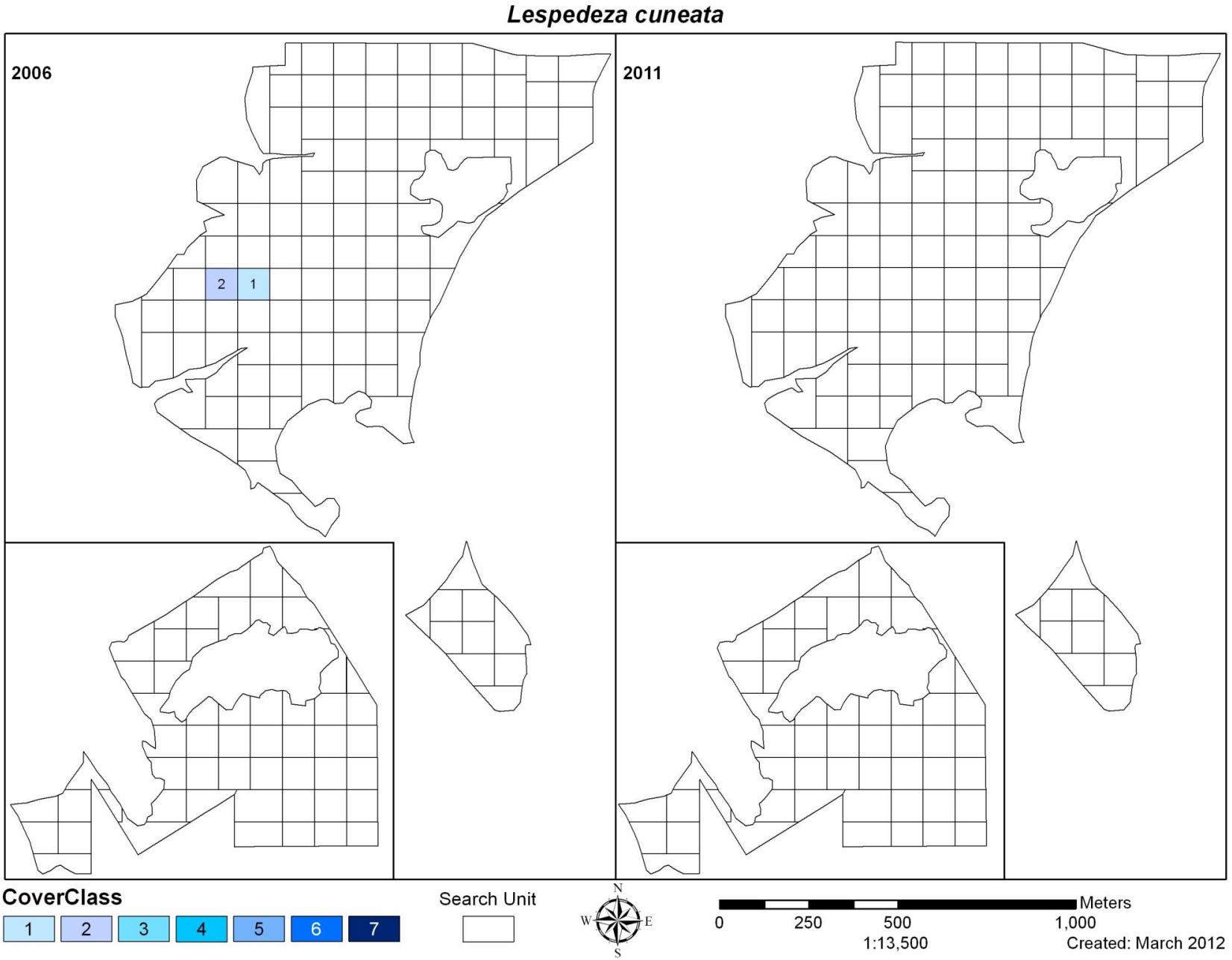

Figure 20. Abundance and distribution of *Lespedeza cuneata* (sericea lespedeza) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

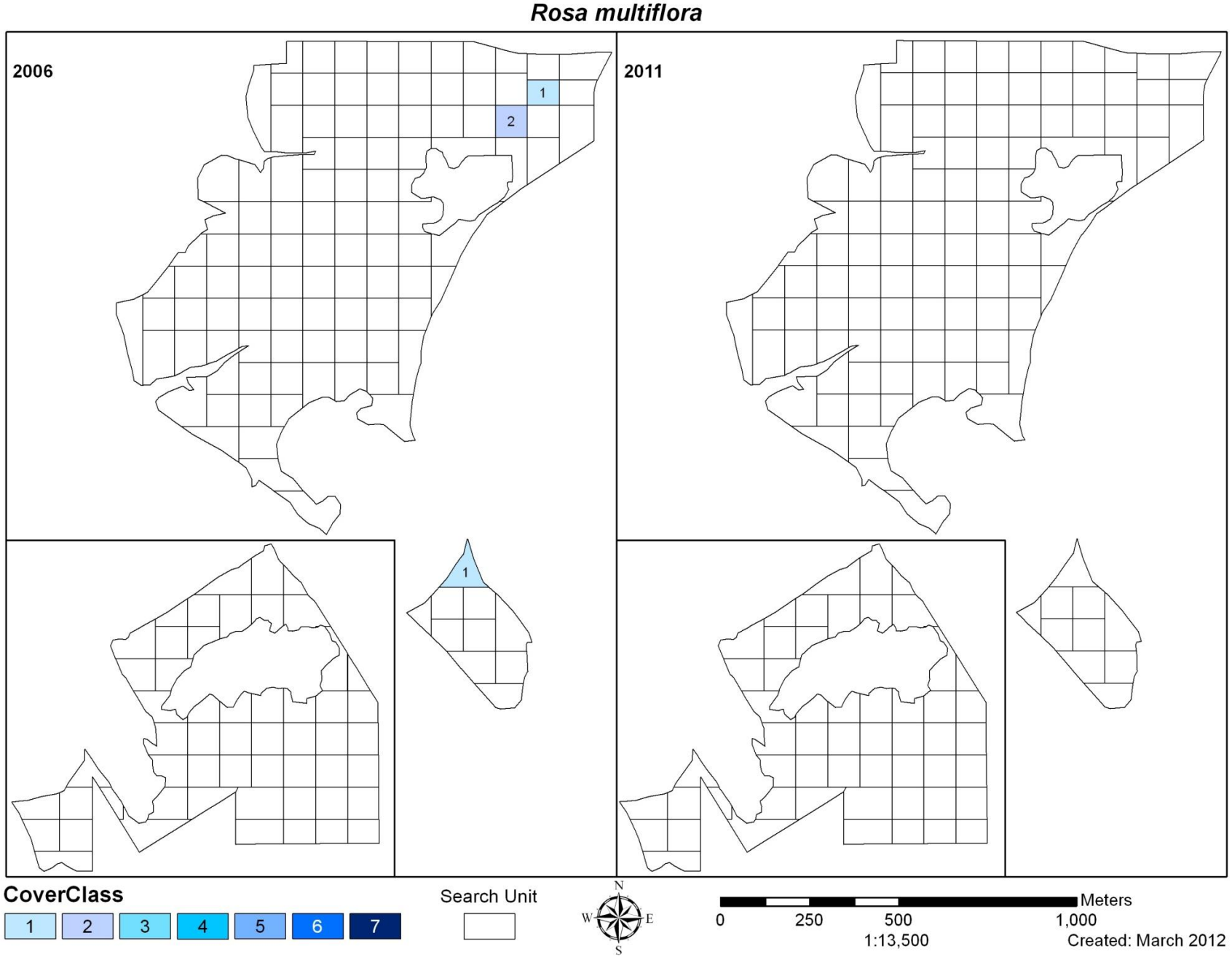

Figure 21. Abundance and distribution of *Rosa multiflora* (multiflora rose) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

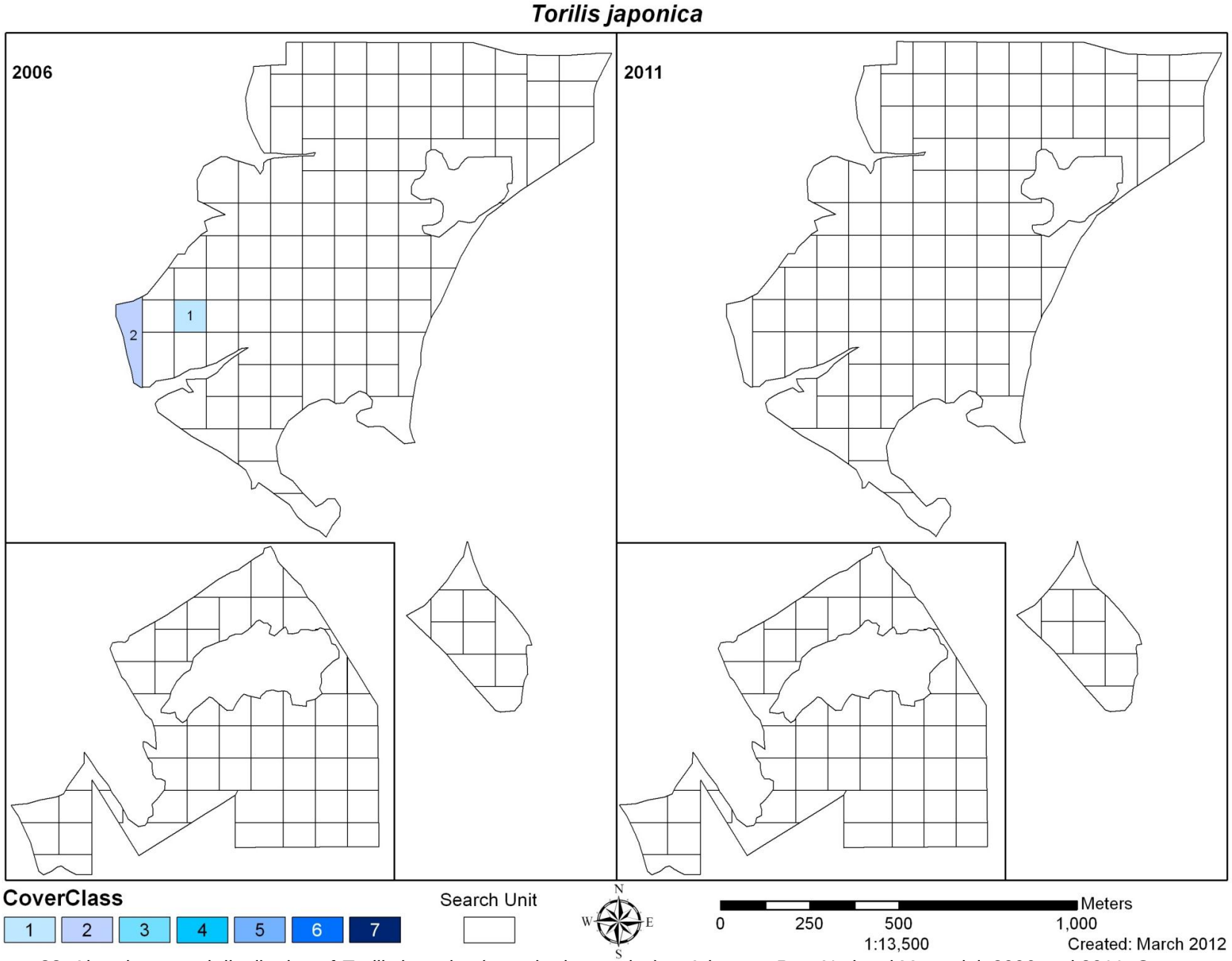

Figure 22. Abundance and distribution of *Torilis japonica* (erect hedgeparsley) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

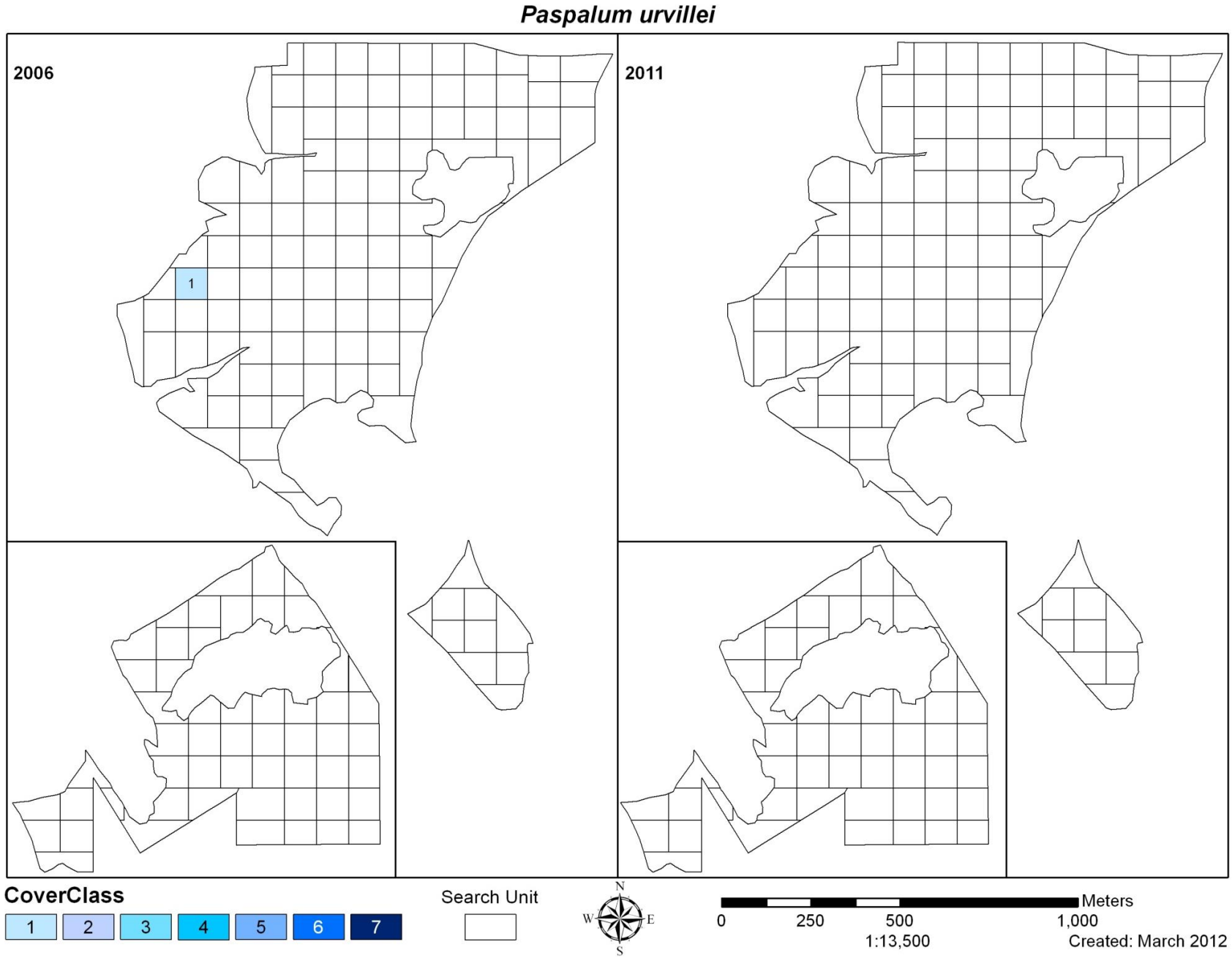

Figure 23. Abundance and distribution of *Paspalum urvillei* (vasey's grass) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

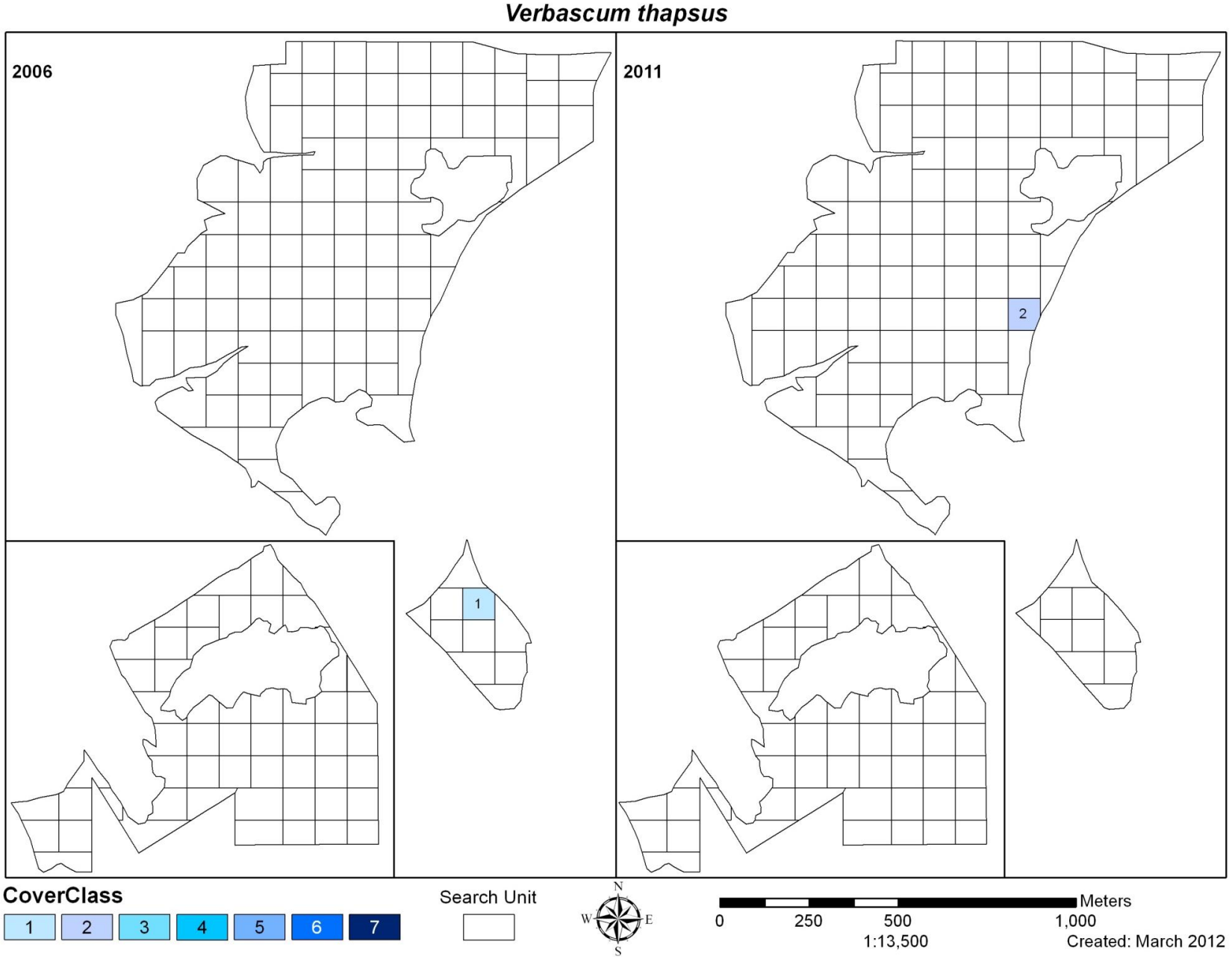

Figure 24. Abundance and distribution of *Verbascum thapsus* (common mullein) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

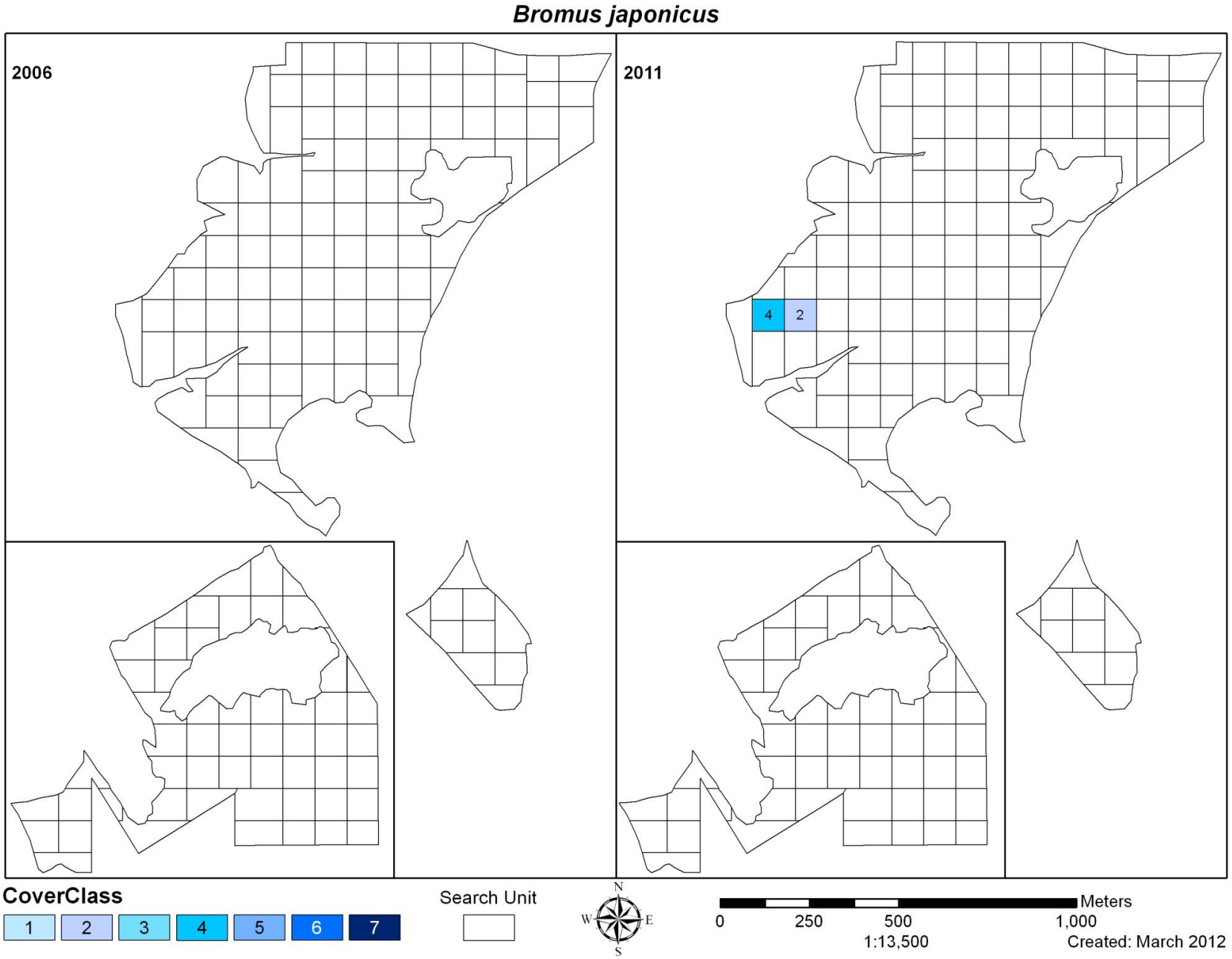

Figure 25. Abundance and distribution of *Bromus japonicus* (Japanese brome) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

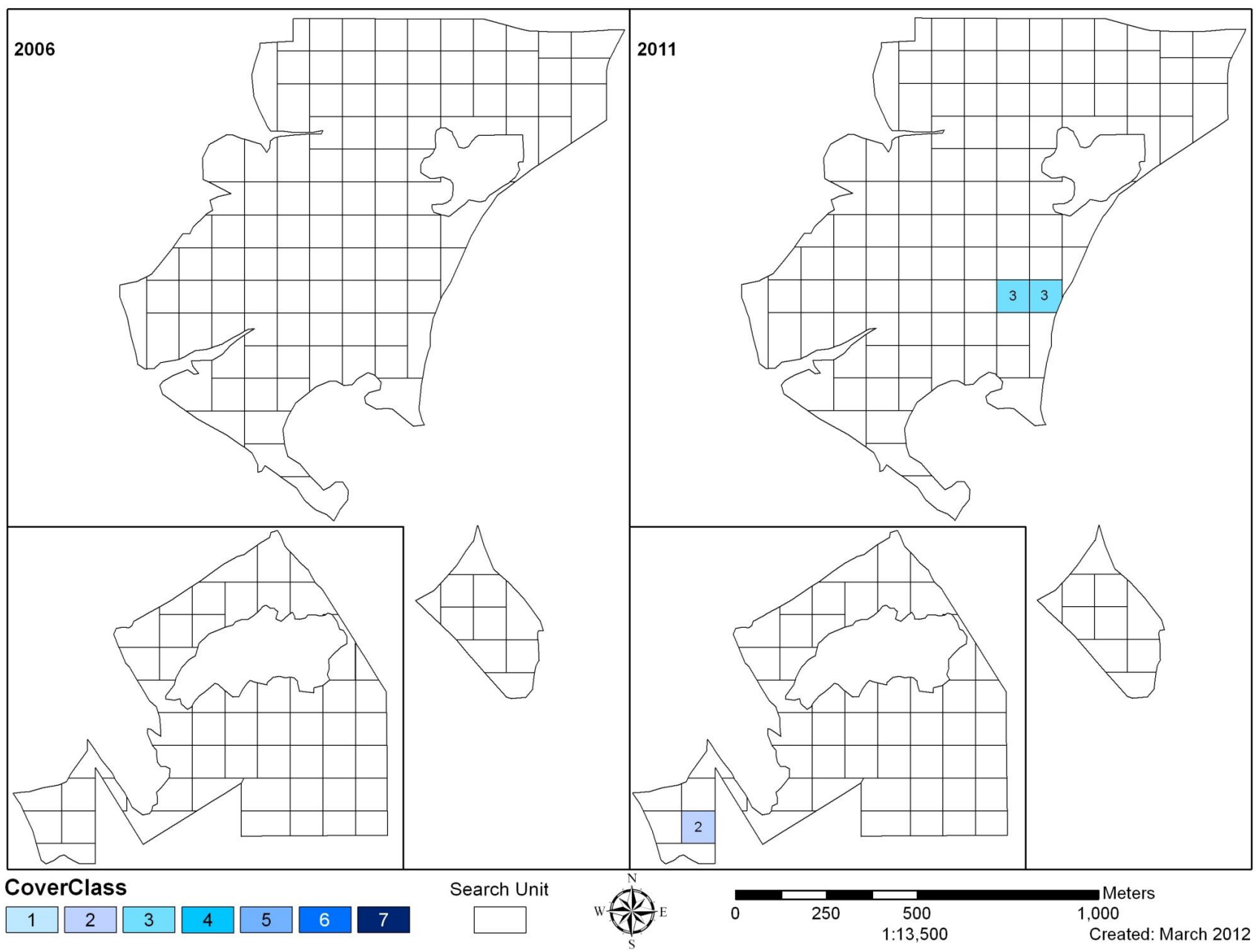

Figure 26. Abundance and distribution of *Wisteria sinensis* (Chinese wisteria) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

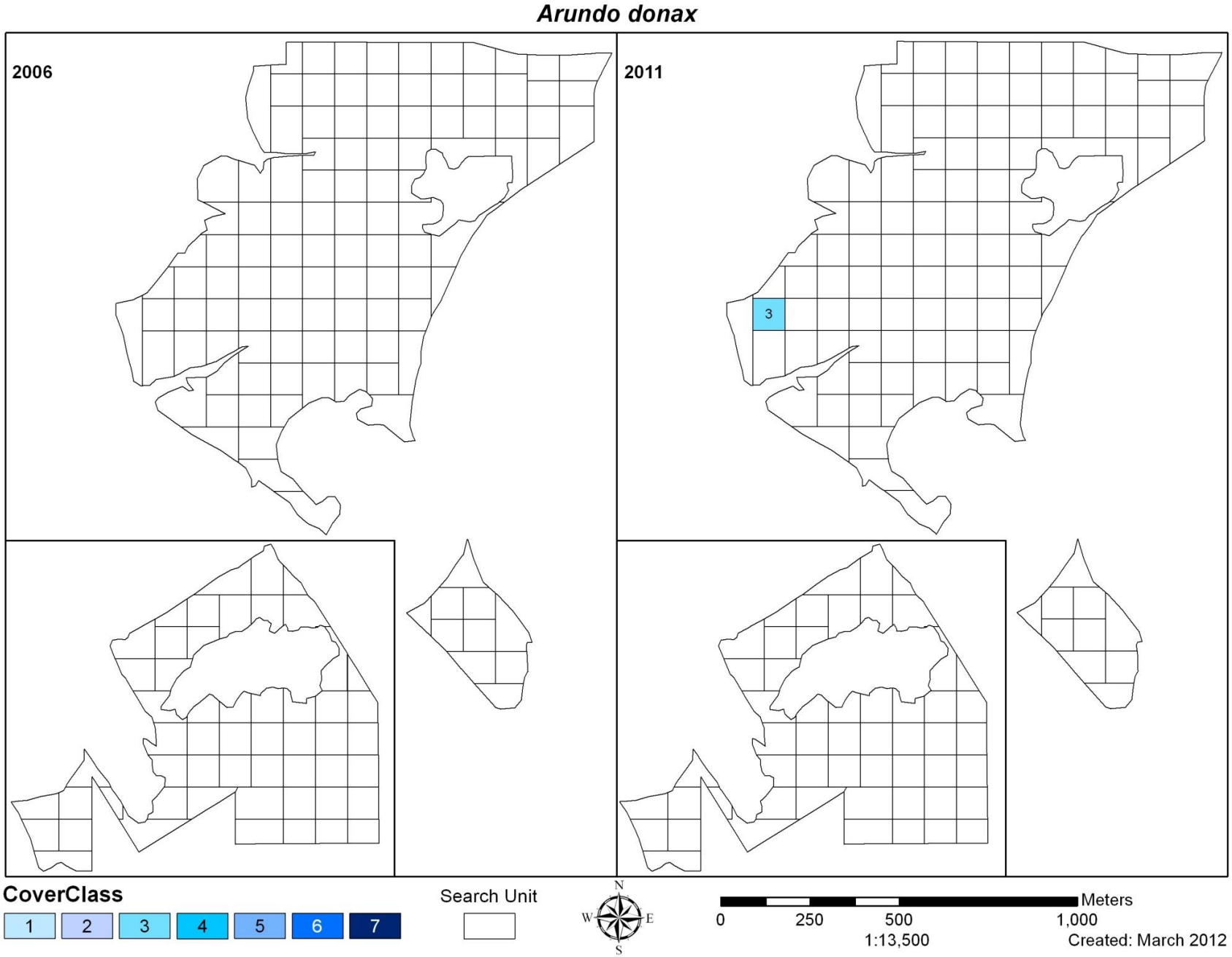

Figure 27. Abundance and distribution of *Arundo donax* (giant reed) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

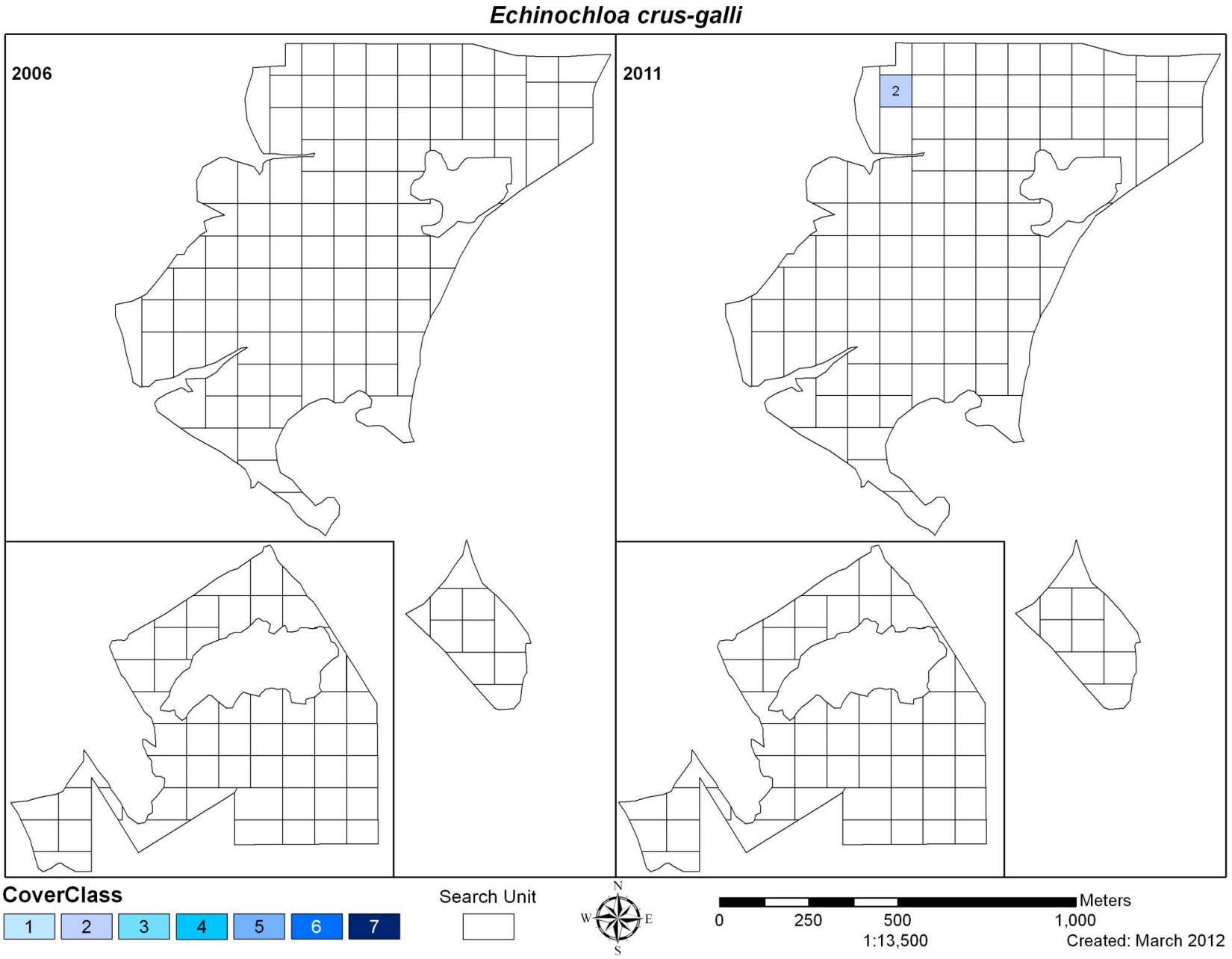

Figure 28. Abundance and distribution of *Echinochola crus-galli* (barnyard grass) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

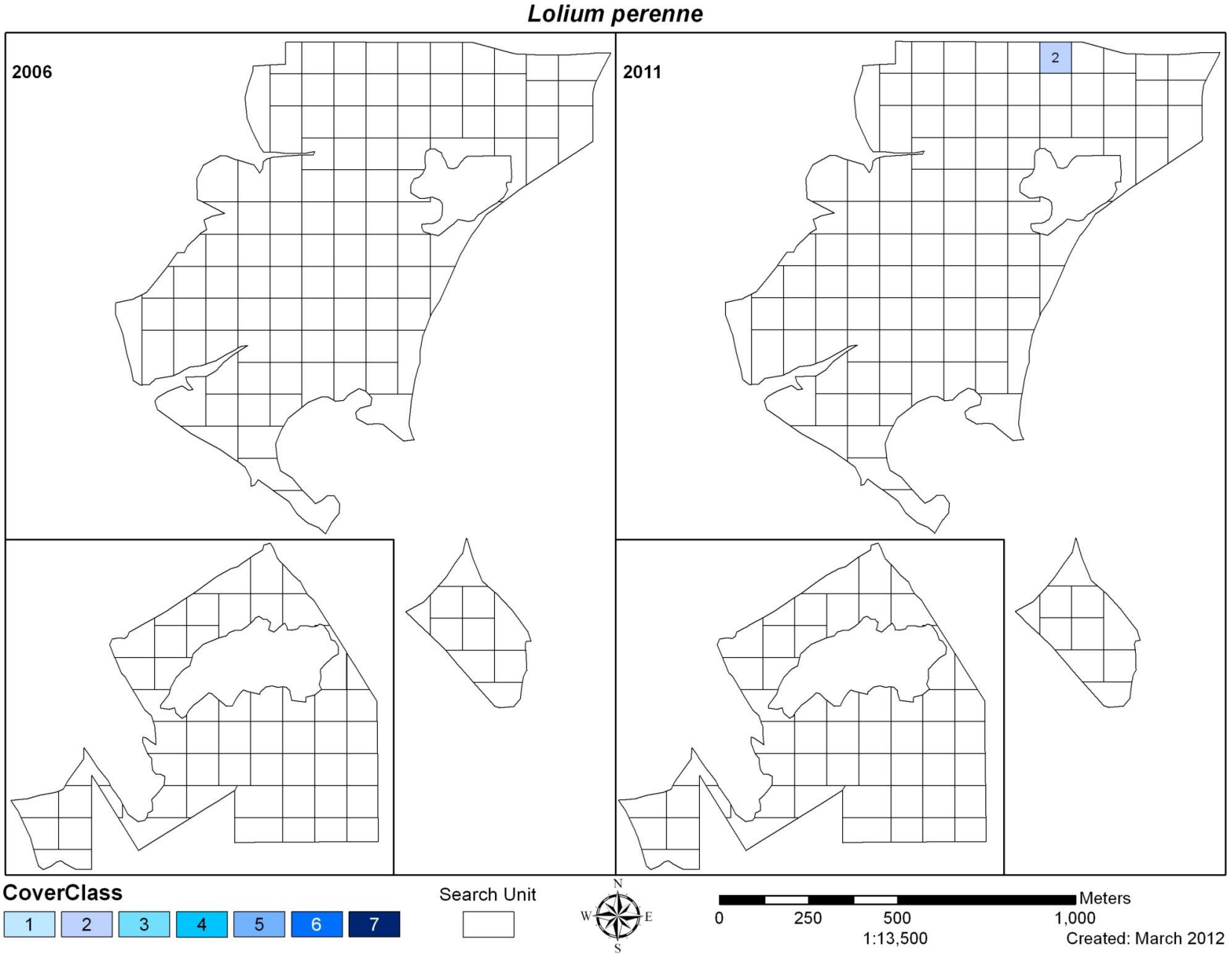

Figure 29. Abundance and distribution of *Lolium perenne* (perennial ryegrass) at Arkansas Post National Memorial, 2006 and 2011. Cover classes per search unit are as follows: 1=0.1-0.9 m^2, 2=1-9.9 m^2, 3=10-49.9 m^2, 4= 50-99.9 m^2, 5=100-499.9 m^2, 6= 500-999.9 m^2, 7= 1,000-4,999 m^2.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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U.S. Department of the Interior

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